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Linkages Between Performance and Institutions in the Primary and Secondary Education Sector

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LINKAGES BETWEEN PERFORMANCE AND INSTITUTIONS IN THE PRIMARY AND SECONDARY EDUCATION SECTOR

ECONOMICS DEPARTMENT WORKING PAPERS No. 558

by Douglas Sutherland and Robert Price

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ABSTRACT/RÉSUMÉ

Linkages between performance and institutions in the primary and secondary education sector

The efficiency of schools diverges dramatically across countries in the OECD and can also vary markedly within countries. These differences in levels of efficiency can be traced to policy and institutional settings. As such, moving to best practice could boost educational attainment and reduce pressure on budgetary resources. This paper assesses empirically the relationship between institutional and policy settings and the efficiency of public spending on primary and secondary education across OECD countries. The analysis builds on two previous papers, which respectively developed OECD-area indicators of educational efficiency based on PISA score data and institutional indicators based on questionnaire responses. The results identify a number of institutional and policy settings that appear conducive to raising efficiency, as well as policies that appear to be detrimental to achieving higher levels of efficiency.

JEL classification: H52; I21; I22; I28

Keywords: Education; public spending; efficiency; institutional indicators

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Liens entre les indicateurs d'efficacité et les indicateurs institutionnels dans le secteur de l'enseignement primaire et secondaire

L'efficacité des établissements scolaires varie énormément dans les pays de la zone OCDE et peut aussi varier sensiblement à l'intérieur d'un même pays. Ces différences de niveaux d'efficience peuvent être attribuées aux politiques publiques et aux structures institutionnelles. De ce fait, s'orienter vers les meilleures pratiques pourrait stimuler les performances des systèmes scolaires. Cet article évalue de manière empirique la relation entre les structures institutionnelles, les politiques gouvernementales et l'efficacité des dépenses publiques consacrées à l'éducation primaire et secondaire dans les pays de l'OCDE. Cette analyse s'appuie sur deux précédentes études, l'une qui a élaboré des indicateurs au niveau de la zone OCDE de l'efficacité des systèmes éducatifs à partir des scores PISA, l'autre des indicateurs des structures institutionnelles à partir des réponses à un questionnaire. Ceci conduit à identifier un certain nombre de structures institutionnelles et de politiques publiques qui semblent induire une efficience accrue, mais aussi des politiques qui semblent nuire à une amélioration des niveaux d'efficacité.

Classification JEL : H52; I21; I22; I28

Mots clés : Éducation ; dépenses publiques ; efficacité ; efficience ; indicateurs institutionnels

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LINKAGES BETWEEN PERFORMANCE AND INSTITUTIONS IN THE PRIMARY AND SECONDARY EDUCATION SECTOR

By Douglas Sutherland and Robert Price[1]

1. Introduction and main results

1. The aim of this paper is to identify empirically the institutional and policy settings that best contribute to the efficiency of public spending on primary and secondary education. The analysis builds on two earlier papers: Sutherland, *et al.* (2007) and Gonand *et al.* (2007). The first of these papers developed indicators of educational efficiency, based on PISA score data, using both aggregate national-level data and a much larger sample of individual school-level data. Based on questionnaire responses by national authorities, the second paper compiled composite country-level indicators of institutional settings that *a priori* could affect educational outcomes, grouped under the three headings of quality in resource allocation (*allocative quality*), budget management (*budget quality*) and service provision (*market quality*).[2] In addition to these indicators of national institutional settings, the current paper also draws on information about a more restricted set of institutional features available for individual schools in "the PISA database". On this basis, the paper attempts to link the indicators of educational efficiency to those for institutional quality (and its component characteristics) using a simplified reduced-form empirical framework applied at both the country and the school level.

2. The main findings are as follows:

- There are a number of institutional and policy settings that appear conducive to raising educational efficiency. Greater decision-making autonomy at the school-level tends to be associated with higher levels of efficiency, as are assessment policies that monitor student performance and allow for benchmarking between schools. There is also some evidence that employing more qualified teachers can compensate for having fewer teachers.

- A number of fairly common practices appear to be detrimental to efficiency. In the first place, small school size and residence-based selection, which is widespread among OECD countries, tend to be associated with greater inefficiency. Inefficiency also tends to be greater when schools stream pupils.

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1. The authors are members of the Economics Department of the OECD. They are indebted to the participants of the March 2007 meeting of Working Party No. 1 of the OECD Economic Policy Committee, to the Delegates of the Education Policy Committee and to Mike Feiner, Jørgen Elmeskov and other colleagues for their useful comments. The authors are grateful to Chantal Nicq for statistical assistance and Veronica Humi, Paula Simonin and Sandra Raymond for secretarial assistance. The opinions expressed in this paper are those of the authors and are not necessarily shared by the OECD.

2. The performance indicators are described in Sutherland *et al.* (2007), together with explanations of the procedures used. The institutional indicators are described in Gonand *et al.* (2007).

- No systematic relationship could be identified at the national level between educational efficiency and the composite indicators of institutions affecting allocative quality. However, within-country variation in efficiency at the school level, and hence the gains to be made from adopting national best practice, tends to be smaller when a country has high scores with respect to the allocative quality of its institutions.

- As would be expected, countries registering higher scores for quality in the budget management indicator (with a relative dependence on an outcome-focused approach and managerial autonomy) tend to be more successful in restraining input use for a given level of educational attainment. However, it proved impossible to establish a link between the quality of institutions allowing market-type competition (which includes benchmarking and user choice) and educational efficiency.

3. The structure of the rest of the paper is as follows. The data sources, explanatory variables and estimation procedures are described in Section 2. The results of the regression analysis are then given, first for the country level (Section 3) and second for the school level (Section 4). Supplementary results are presented in an Annex.

2. Explaining differences in efficiency: methodological issues

4. This section begins by reviewing the main features of the indicators of efficiency, which are used as the dependent variables. It then highlights some of the key features of the indicators of institutional settings that are used as explanatory variables, as well as other "environmental" variables that may impinge on educational efficiency. Finally, the section gives a brief overview of the estimation techniques used and discusses their limitations.

The data: dependent and explanatory variables

5. Sutherland *et al.* (2007) discussed and quantified sets of efficiency indicators of educational performance in primary and secondary education, based on the construction of "efficiency frontiers" derived, on the output side, from PISA 2003 data on the average level and homogeneity of educational attainment, the main inputs being the quantity of teachers relative to students and measures of the socio-economic background of the students. The efficiency indicators were estimated by identifying the potential gains from moving to best practice and differ according to the assumptions about the returns to scale, which determine the shape of the efficiency frontier (Box 1). They also depend on whether the efficiency estimate is measured in terms of the extent to which inputs could be reduced while holding outputs constant (input orientation) or how much outputs could be boosted while holding inputs constant (output orientation). A distinction is also made between technical and cost efficiency, the latter incorporating the relative price of inputs (mainly teachers' wages in this case) as well as their quantity. The analysis that follows uses all of the resulting efficiency indicators to explore the effects of policy settings.[3]

6. Given that the estimates of efficiency already control for the socio-economic background of the student,[4] the main explanatory variables of cross-country differences in the production function are assumed to be policy related. In this respect, for the country-level analysis three main policy domains are

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3. The estimates of efficiency use statistical techniques to assess and correct possible biases that can arise when the data are limited or sparsely distributed. Greater detail on the procedures used is given in Sutherland *et al.* (2007).

4. In Hanushek's literature review, one of the minimal requirements for inclusion was that the empirical estimation included a "family background" variable (Hanushek, 1996).

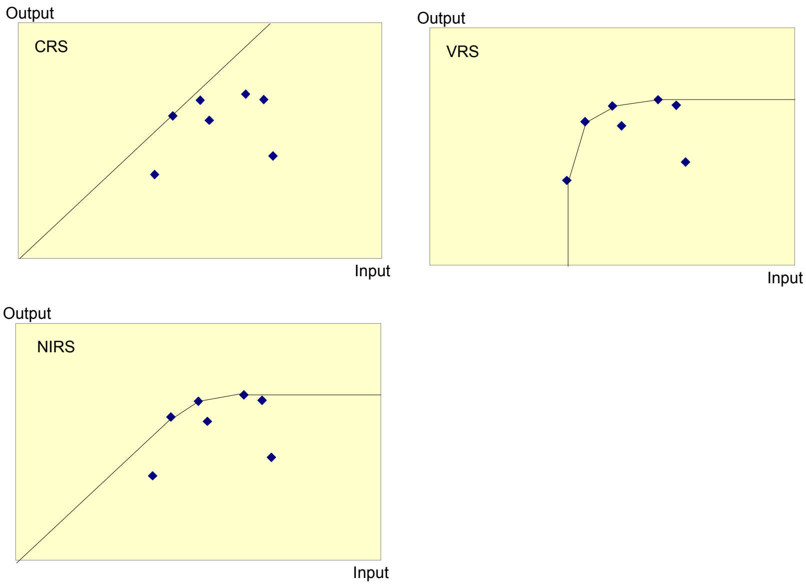
Box 1. **Data envelopment analysis**

Data envelopment analysis (DEA) constructs an efficiency frontier based on the input and output data from all the countries/schools of a sample. In essence, as shown in the figures below, the frontier is constructed from the schools or countries that *envelop* the remaining observations and thus provides a benchmark by which the others can be judged. By assumption, the frontier determines best practice, and potential efficiency gains for specific countries or schools are measured by their position relative to the frontier or the envelope. In the "one input-one output" case given in the figures, a measure of the efficiency shortfall in terms of unachieved output is given by the ratio of a school's output to the output on the frontier for the same level of inputs (*i.e.* the point on the frontier vertically above the school/country observation). Conversely, the ratio of inputs on the frontier to the school's inputs at the same output (measured horizontally) is a measure of inefficiency in terms of potentially excess inputs. In the case of multiple inputs or outputs, the measures of efficiency are determined in a similar fashion by holding the relative proportions of either inputs or outputs constant in measuring the distance to the frontier. Countries or schools can then be benchmarked on the basis of potential efficiency gains compared to the measures of best practice.

The shape of the DEA efficiency frontier depends on the assumptions about returns to scale:

- *Constant returns to scale (CRS)*. This assumption describes the efficiency frontier as a ray from the origin through the observation(s) with the highest output/input ratio (Box figure, upper left panel).
- *Variable returns to scale (VRS)*. This approach identifies the schools or countries that define the frontier by starting from the observations of units that use the least of each input and ending with the observations producing the highest amount of each output (upper-right panel).
- *Non-increasing returns to scale (NIRS)*. This assumption combines the constant returns to scale assumption between the origin and the observation with the highest output/input ratio, and variable returns to scale thereafter (lower left panel).

Box Figure. DEA efficiency frontiers



identified: quality in resource allocation; quality in budget management, and quality in market frameworks (Box 2). The broad structure of the indicators is shown in Figure 1 and data are given in the Annex (Table A4). Composite indicators for policies in these three domains are used in this paper as measures of the policy settings that are likely to influence national differences in educational efficiency.[5] These composite indicators can be aggregated further into overall composite indicators; but such a high level of aggregation appears to mask the influence of policy settings on measures of efficiency.[6]

Box 2. **The structure of institutional indicators**

Quality in resource allocation

Two important indicators of an ability to allocate resources efficiently are defined as follows:

- The degree of decentralisation of responsibilities between central government and sub-national public authorities is taken as improving efficiency in the allocation of public spending resources insofar as educational needs may differ from one geographical area to another and resources should be matched to them. However, decentralisation may become counterproductive and reduce efficiency if it is poorly designed, resulting, for instance, in overlapping responsibilities between levels of government.

- Matching resources to specific needs -- which can encompass mechanisms to support the disadvantaged -- may have a favourable impact on overall educational efficiency, notably by avoiding "cream-skimming" effects at the aggregate level. Such mechanisms may be required in order to make up for the tendency of education systems to under-provide services for less able pupils.

Quality in budget management

Under the heading of quality in budget management, two crucial efficiency enhancing characteristics may be identified:

- The extent to which policy is outcome-focused allows clear objectives to be set for public institutions involved in education, especially if backed by associated evaluation, reward and/or sanction systems.

- The degree of managerial autonomy, especially at the school level, based on flexibility of job status, wage setting and budget allocation and disciplined by liberalised outsourcing, may also make for greater efficiency in the use of resources.

Quality in market framework

Productive efficiency is presumed to be related to the degree of competitive pressure in service provision, which involves the presence of market signals:

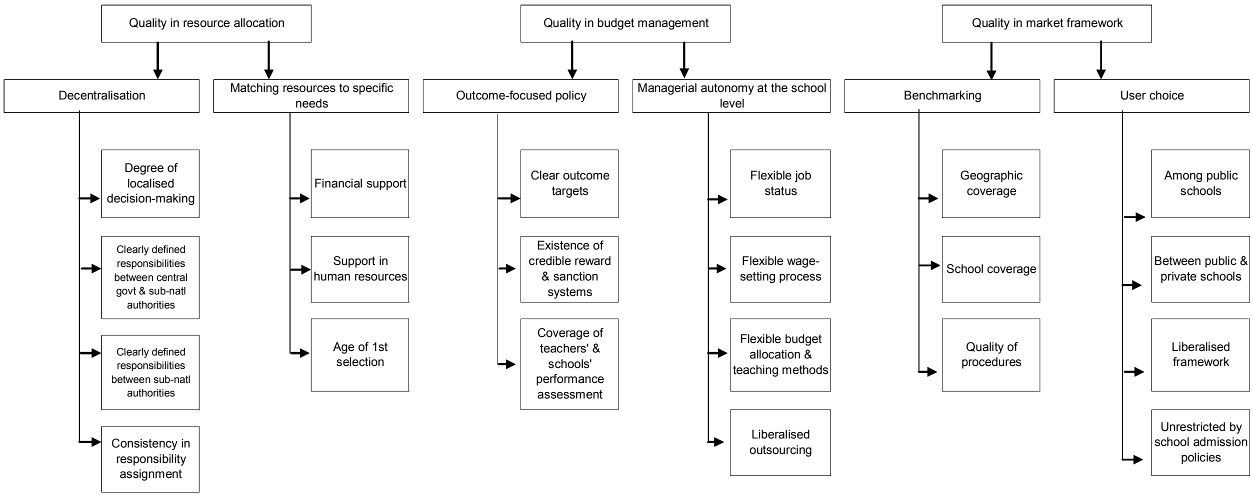
- Benchmarking may improve service provision by identifying best practices and inefficiencies.

- Allowing for user choice among alternative providers of educational services may be one of the most effective means of giving market signals a role in enhancing the effectiveness of public spending in education. This may strengthen competitive pressures and results in services which respond better to citizens' needs -- provided that spending follows the user.

5. In producing each composite indicator, different types of aggregation procedures can be used, depending in part on the potential complementarities between policies in different domains. In each case, three versions of the indicator are calculated and used in the analysis, based on multiplicative and two variants of exponential aggregation.

6. This may be due to the presence of offsetting characteristics at the sub-aggregate level. Some policies help to enhance efficiency by economising on resources; others help by allowing resources to be used more effectively. If the two institutional characteristics are combined into a composite indicator, it may not correlate with indicators of performance measured in either the input saving or output increasing direction.

Figure 1. **Structure of institutional indicators**



7. The country-level data are limited to the very small sample of OECD member countries -- less than 30 observations, which severely limits the possible empirical analysis. Hence, the analysis in this paper is also conducted using school-level data, which builds on a vastly larger sample of typically over 5 000 schools. The two approaches are intended to be corroborative and complementary.[7] In order to exploit the much larger dataset of school level efficiency estimates, responses to the PISA 2003 school-level questionnaire can be used to test the influence of institutions and policies which are components of the country-level institutional indicators. In particular, the PISA responses give school-level information with respect to aspects of: decision-making autonomy; student assessment and streaming; and school selectivity, as well as types of ownership. Descriptive statistics for these school-level data are given in the Annex (Table A6).[8] At the same time, the national institutional indicator data set has been complemented by a set of national institutional variables available from the OECD publication *Education at a Glance* (2004), showing the extent of decision-making autonomy given to schools in various domains. These indicators are used to supplement analysis at the country level (Table A5).

8. The estimations at both the national and school level were augmented with variables to control for possible differences in the quality of teaching inputs.[9] At the national level, a variable for the relative

7. Estimates of technical efficiency at the national level and for the median school, together with estimates of cost efficiency at the national level, are given in Annex Tables A1-A3). In general, the school-level estimates of efficiency have smaller confidence intervals around the point estimates of the level of technical efficiency. In order to simplify some of the estimations used later in the paper, the efficiency estimates are the inverse of the estimates presented in Sutherland *et al.* (2007). Thus, a negative estimated coefficient suggests a relation with lower levels of inefficiency.

8. Apart from the composite indicators already available in the PISA 2003 database, the variables derived are mainly dummy variables, which assign a value of one if the school implements a given policy and zero otherwise.

9. A variable for population density -- to account for the possible burden of providing education in countries where geographic dispersion is high -- was also used in preliminary testing. However, this variable did not reveal any significant relationship with efficiency at the aggregate level, perhaps due to the crudeness of the measure for a country as a whole. This variable is dropped in the results reported.

remuneration of career teachers (*Education at a Glance* reports a teacher's wage after 15 years relative to *per capita* GDP) was included to capture possible differences in the quality of teaching personnel. However, as GDP *per capita* reflects not only national productivity levels but is influenced also by employment rates, this variable is at best a rough proxy. At the school level, the main quality variable used was taken from the PISA school questionnaire on the certification or qualifications of the teaching staff. The school-level database also contained responses on the assessment of the quality of pedagogical and building resources, which were used in the analysis as well.

Estimation procedure

9. The estimation procedure uses the dependent variables and explanatory variables described above in a regression to evaluate the possible influence of institutional settings on the measures of efficiency performance. (The method employed is set out in Box 3.) The empirical approach adopted faces two main obstacles in identifying the influence of policy on performance. One drawback is that the indicators for the institutional environment are based on information concerning 2006, though the estimates of efficiency are based on education received mainly during the 1990s, as captured by the PISA 2003 survey. This may not be too problematic if the institutional framework of education systems or for individual schools has been relatively unchanged. But, in some cases, quite radical reforms have been implemented over the past decade. A second limitation is the cross-sectional nature of the data. Results are limited to identifying empirical relationships that lend plausible support to the possible role of institutional settings in affecting efficiency, but causality could be different.

10. The two-stage procedure used to assess institutional and policy influences on efficiency, whereby indicators of efficiency are first created and then regressed on institutional indicators, might, in principle, be replaced by a single-stage process in which policy and institutional factors were incorporated as controls at the production function stage. However, the accuracy of the estimation using non-parametric techniques falls dramatically as the number of variables used in the specification rises. In addition, DEA estimates are sensitive to the inclusion of irrelevant variables. Given these limitations, the two-step approach provides a suitable framework to test for the significance of institutional variables *expected* to influence efficiency. While a two-step approach has limitations -- there may indeed be biases in either direction due to the omission of policy variables from the estimates of efficiency -- results from parametric regressions using stochastic frontier analysis at the school-level provide a check on the robustness of the non-parametric findings.[10]

3. Institutional settings and efficiency at the country level

11. An examination of the relationship between institutional indicators and efficiency indicators at the country level is based on an extremely small sample. In this context, specifications are kept relatively simple, though it should be noted that some results are sensitive to these simplified specifications. For this reason, the results presented in this section should be treated with some caution.

10. Estimates derived from stochastic frontier analysis, which require that the production function be explicitly specified, are also less rich than the two-stage DEA results, since they can vary according to whether the efficiency measure is in terms of input saving or output boosting and the assumptions about the returns to scale.

Box 3. **Estimation procedure**

Truncated regressions

The distribution of efficiency estimates is truncated at the point of observed best practice and this needs to be taken into account in the estimation procedure. Maximum likelihood techniques are available to estimate truncated regressions,[1] with the general form of the truncated regression given by :

$$\hat{\delta}_i = \beta' z_i + \varepsilon_i$$

The log likelihood function for the (left) truncated regression estimates used in this paper is:

$$\ln L = -\frac{n}{2}(\ln(2\pi) + \ln\sigma^2) - \frac{1}{2\sigma^2}\sum_i(\hat{\delta}_i - \beta' z_i)^2 - \sum_i \ln\left[1 - \Phi\left(\frac{1-\beta' z_i}{\sigma}\right)\right]$$

Measurement error affecting observations on the efficiency frontier can create complicated patterns of serial correlation for observations that lie within that portion of the frontier. This is particularly a problem at the tails of the distributions that determine the efficiency frontier. One possibility to address this -- adopted recently by a number of authors -- is to bootstrap the truncated regression model (Simar and Wilson, 2007; Afonso and St. Aubyn, 2006). "Pseudo data" are generated from a truncated normal distribution and repeatedly used as the dependent variable using the same explanatory variables (as described below).[2] The resulting estimates are then used to construct confidence intervals for the point estimates from the original truncated regression.

The bootstrap procedure using pseudo data is performed as follows:

Use the maximum likelihood estimator to estimate $\hat{\beta}$ and $\hat{\sigma}_\varepsilon$ for the truncated regression $\hat{\delta}_i = \beta' z_i + \varepsilon_i$ with $\varepsilon_i \sim N(0, \sigma_\varepsilon^2)$

Next, loop over the following steps (in the estimations 2 000 loops were used)

1. for each i=1,…,m where $m \leq$ n draw $\hat{\varepsilon}_i$ from $\varepsilon_i \sim N(0, \sigma_\varepsilon^2)$ with left truncation at $(1 - \beta' z_i)$ The method to draw from the left-truncated normal distribution is as follows: Let $\Phi(\cdot)$ and $\Phi^{-1}(\cdot)$ denote the standard normal distribution and the standard normal quantile function, respectively. Generate v to be uniform on (0,1) and set $c' = 1/\sigma$ to calculate $v' = \Phi(c') + (1 - \Phi(c'))v$. Then compute $u = \sigma\Phi^{-1}(v')$
2. compute $\delta_i^* = \beta' z_i + \hat{\varepsilon}_i$
3. Use the maximum likelihood estimator for the truncated regression $\hat{\delta}_i^* = \beta' z_i + \varepsilon_i$ to estimate $\hat{\beta}^*$ and $\hat{\sigma}_\varepsilon^*$

Finally, use the bootstrap values to construct confidence intervals around the original estimates of $\hat{\beta}$ and $\hat{\sigma}_\varepsilon$

Stochastic frontier analysis

Stochastic frontier analysis is similar to standard regression techniques but differs by exploiting the one-sided nature of inefficiency to decompose the error term into a standard error term and an asymmetric component that measures inefficiency. Formally, the basic stochastic frontier model is given by:

$$y_i = f(x_i, \beta) + \nu_i - \upsilon_i$$

where, y_i is the output of school i, f(.), is a measurable production function, x_i are exogenous variables, $ß$ is a vector of unknown parameters and v_i-u_i is the composed error term consisting of v the symmetric disturbance and u the non-negative disturbance measuring the inefficiency of the school. There are a number of different types of assumptions concerning the distribution of the inefficiency, including half-normal and exponential.

The estimates augment the translog production function used in Sutherland *et al.* (2007) with the different measures of policies reported at the school level. These estimates report cluster robust standard errors (z statistics) in order to take into account the possible lack of independence of policies across public and private schools within a country.

1. Alternative approaches used to explain inefficiency, such as Tobit analysis, which is often used in the empirical literature, will lead to inconsistent estimation (Maddala, 1983). The approach adopted in this paper does not take account of the possible truncated distribution of the institutional indicators or the fact that the dummy variables are categorical (that is the variable is either 0 or 1). Zelenuyk (2005) reports that the test for significance for the coefficients of dummy variables will tend to show statistical significance only when the differences in the efficiency levels between the groups identified by the dummy variables are large.
2. It is also possible to use a bootstrap on the empirical distribution, though this is potentially inconsistent.

12. The analysis here explored a number of specifications (Table 1), using estimates of technical efficiency for each country's "median school" from the school-level database as well as the estimates of technical and cost efficiency from the country-level sample.[11] Efficiency is measured in both the input-saving and output-increasing direction and in each case there are three versions of these indicators which differ according to the assumptions about returns to scale. Results are only reported under the assumption of non-increasing returns to scale in Table 1 (additional specifications being reported in the Annex). The

Table 1. **Correlations between efficiency scores and institutional indicators**
Efficiency measured assuming non-increasing returns to scale

	Efficiency indicators							
	Input orientation				Output orientation			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	A. Technical efficiency for the median school							
Institutional indicators								
Resource allocation	..-			...	...			...
Budget management		+++		+++		...		...
Market framework			...	...			...	...
Relative teachers' remuneration	+++	+++	+++	+++	+++	+++	...	...
Same results with other returns to scale assumptions	No	Yes	Yes	Yes	No	No	No	No
	B. Technical efficiency at the national-level							
Institutional indicators								
Resource allocation	..-			...	...			...
Budget management		...		...		...		...
Market framework			...	...			...	...
Relative teachers' remuneration	+++	+++	+++	+++	...	...	...	...
Same results with other returns to scale assumptions	Yes	Yes	Yes	Yes	Yes	No	No	No
	C. Cost efficiency at the national-level							
Institutional indicators								
Resource allocation	.--			...	...			...
Budget management		...		...		...		...
Market framework			...	...			...	...
Relative teachers' remuneration	+++	+++	..+	+++	...	...	...	..+
Same results with other returns to scale assumptions	Yes	Yes	No	Yes	No	No	Yes	No

Note: + signifies a positive correlation with higher levels of efficiency, a - signifies a negative correlation, while a dot indicates the relationship was not statistically significant. The results are for each specification using the institutional indicators and different methods of their aggregation. Thus, if a positive correlation holds for an institutional indicator using all three aggregation methods, the cell will record three plus signs.

11. The median school is used in the assessment of country-level institutional settings not only to check against possible aggregation biases (Hanushek, 1996) but also because the point estimates of efficiency from the country-level sample are subject to considerable uncertainty. This is an unavoidable drawback of DEA analysis on small samples.

set of explanatory variables combines relative teachers' remuneration in four different configurations of explanatory variables, namely the indicator of resource allocation (columns 1 and 5 in Table 1); budget management (columns 2 and 6); market framework (columns 3 and 7), and all three indicators (columns 4 and 8). The institutional indicators also vary according to the three different aggregation methods employed in their construction (multiplicative and two variants of exponential aggregation).

13. The results do not reveal a systematic relationship between the performance indicators and the country-level composite indicators for institutional settings. Panel A reports results for estimations using the level of technical efficiency for the "median school" as the dependent variable. A higher level of quality in budget management is positively correlated with higher efficiency, as measured by the extent of possible resource savings (columns 2 and 4), while the policy indicator for quality in resource allocation generally does not play a significant role (columns 1 and 4).[12] Panel B reports results using the level of *technical* efficiency from the country-level sample as the dependent variable, which confirm the above negative result with respect to the policy indicator for quality in resource allocation. In these specifications, the policy indicator for budget management is no longer significant. Panel C reports results relating to *cost* efficiency from the country-level sample, with similar results.

14. Relative teachers' remuneration emerges as positively related to technical efficiency in most specifications when efficiency is measured as potential savings in inputs.[13] The various explanatory variables are generally not statistically significant when the efficiency indicator is measured in the output orientation, probably reflecting the smaller degree of policy-related variation in comparison to input-oriented efficiency indicators.

15. A second set of regressions at the country level examines whether the performance indicators are related to the extent to which decisions are devolved to the school level, using information from *Education at Glance* (OECD, 2004). (This component of decision making is included in the resource allocation indicator, used in the previous set of regressions, but is here incorporated separately.) These regressions reveal a reasonably consistent picture of better education performance in countries where decentralisation is more pronounced (Table 2).[14] The potentially beneficial effects of autonomy over the organisation of instruction (columns 2 and 7) and, to a slightly lesser extent, planning -- including such decisions as whether to open or close a school and programme design -- (column 4) are particularly striking.

16. The composite institutional indicators and intermediate indicators do, however, play a more positive role in explaining the *variation* in school-level efficiency scores within countries (Table 3). The variation in school-level efficiency is measured as the difference in the efficiency levels of the schools at the 5th and 95th percentiles. The results suggest that there is less variation in school-level efficiency when there is a more favourable institutional setting, as measured by the composite indictor. The indicator is negatively correlated with the measure of variation in efficiency performance in two of the three

12. These results also hold when the efficiency indicator is constructed using a different assumption about returns to scale.

13. Alternative possible measures of teacher quality derived from the PISA 2003 database used in the school-level analysis are typically insignificant, however. In these specifications, the coefficient of the indicator for market frameworks suggests a positive relationship with inefficiency in some specifications.

14. See Bishop and Woessmann (2004) on the importance of school-level decision-making autonomy. Barankay and Lockwood (2006) using data from Swiss cantons show that greater autonomy is correlated with higher levels of student attainment.

Table 2. **Cross-country correlations between efficiency scores and decentralisation**

	Technical efficiency for the median school									
	Input orientation					Output orientation				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Aspects of decisions made at school-level										
All domains	+++					..+				
Instruction		+++					+++			
Personnel			..+					..+		
Planning				+++					..+	
Resources					…					…
Relative teachers' remuneration	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++

Note: + signifies a positive correlation with higher levels of efficiency, a - signifies a negative correlation, while a dot indicates that the relationship was not statistically significant . The results are for efficiency measures using different assumptions about returns to scale. Thus, if a positive correlation holds for an efficiency indicator using all assumptions about returns to scale, the cell will record three plus signs.

Table 3. **Within-country variation of efficiency and institutional settings**

Cross correlations between institutional indicators and the range containing the middle 90% of school efficiency scores

	Cross correlations	
	Input orientation	Output orientation
Multiplicative aggregation		
Composite indicator	-0.340*	-0.314
Budget management	-0.184	-0.027
Market efficiency	-0.255	-0.255
Resource allocation	-0.340*	-0.446**
Exponential aggregation, low		
Composite indicator	-0.101	0.033
Budget management	-0.152	0.020
Market efficiency	-0.151	-0.205
Resource allocation	-0.303	-0.460**
Exponential aggregation, high		
Composite indicator	-0.387**	-0.370*
Budget management	-0.163	-0.024
Market efficiency	-0.313	-0.321*
Resource allocation	-0.359*	-0.454**

Note : A negative sign indicates lower levels of inefficiency. * and ** signify that the cross correlations are significant at the 10% and 5% level of significance, respectively.

specifications reported (corresponding to the different methods of aggregation employed). Policies that score more highly in the domains of resource allocation are particularly strongly correlated with improved performance within a country. [15]

4. School-level policy settings and efficiency

17. The results for efficiency performance at the school level are built on multivariate baseline truncated regressions (Table 4). The dependent variables are the input-saving and output-increasing estimates of school-level technical efficiency calculated from the PISA 2003 school-level database.[16] The explanatory variables correspond to the components of the institutional indicators of policy settings and are derived from the same database. These variables include the extent of school-level autonomy; the use of streaming within the school; the use of assessment, and the importance of selection for the school; as well as variables describing the size of school; ownership status and proxy measures of the quality of teaching inputs, together with a set of country dummy variables. Where possible, the specific types of policies at the school level are examined in more detail (for example, looking at different types of selection policies rather than aggregate indices concerning the extent of selection). The following paragraphs discuss the results in more detail and present supplementary estimations.

18. In order to provide a check on the robustness of these results, Table 5 reports estimates of stochastic frontier estimates of translog production functions.[17] The specification uses average PISA attainment as the dependent variables and uses as principal explanatory variables the teacher-student ratio, the availability of computers, the average socio-economic and language background of students in the school, which is augmented by the additional explanatory variables used in the truncated regressions. The socio-economic background variable is a school average of the pupils' PISA 2003 Index of Economic, Social and Cultural Status (rebased on the highest number of years of schooling received by a parent which is a sub-component of the index). The language background is measured as the share of the school's pupils that speak a national test language at home. In this context, the estimates report whether the different policy variables are associated with higher (positive coefficient) or lower (negative coefficient) levels of attainment, other things being equal.

Size, ownership and quality of resources

19. The results for the regressions reported in Tables 4 and 5 suggest that the size of school matters for efficiency. The results from the truncated regression suggest that this holds particularly for differences in terms of potential savings in inputs (Table 4, panel A).[18] Figure 2, panel A shows the share of schools that are larger than the size of the median school in the whole sample. Typically schools in less populated settlements are smaller, around one third of the size of schools in more densely populated areas (Figure 2, panel B). Hence, geographical factors in some cases will make it infeasible to shift the distribution of schools towards larger schools, but this may not represent a binding constraint in a number of countries.

15. The negative correlation for the indicator of resource allocation occurs irrespective of the method of aggregation employed in its construction, suggesting a quite robust relationship.

16. The results reported are for the measures of technical efficiency that assume non-increasing returns to scale; additional results are presented in the Annex.

17. Stochastic frontier analysis was used in Sutherland *et al.* (2007) to check the robustness of data envelopment analysis estimates of efficiency.

18. This finding was robust to the different measures of technical efficiency and different specifications reported below. Larger schools are systematically more efficient in all the specifications.

Table 4. **Determinants of technical efficiency at school level**
Effect on inefficiency

	Coefficent estimate	Confidence intervals derived from pseudo distribution	
		Lower (2.5)	Upper (97.5)
Factors affecting inefficiency			
A. Input orientation			
Size (x100)	-0.014 **	-0.016	-0.013
Government-dependent private	-0.014	-0.034	0.005
Independent private	0.054 **	0.026	0.083
Teacher qualifications	-0.040 **	-0.069	-0.012
Autonomy resources	-0.002	-0.006	0.002
Autonomy curricular	0.003	-0.003	0.008
Some streaming	0.019 **	0.060	0.033
Complete streaming	0.034 **	0.021	0.047
Assessment: medium	-0.009	-0.021	0.005
Assessment: high	0.001	-0.015	0.017
Selectivity: considered	0.009	-0.003	0.022
Selectivity: priority	-0.018 **	-0.035	0.000
Selectivity: pre-requisite	-0.037 **	-0.052	-0.021
B. Output orientation			
Size (x100)	-0.006 **	-0.007	-0.005
Government-dependent private	-0.020 **	-0.035	-0.005
Independent private	0.000	-0.023	0.021
Teacher qualifications	-0.027 **	-0.048	-0.005
Autonomy resources	0.003 **	0.000	0.006
Autonomy curricular	0.001	-0.003	0.006
Some streaming	0.020 **	0.009	0.030
Complete streaming	0.031 **	0.020	0.041
Assessment: medium	-0.001	-0.011	0.009
Assessment: high	0.008	-0.004	0.021
Selectivity: considered	0.001	-0.008	0.011
Selectivity: priority	-0.033 **	-0.047	-0.020
Selectivity: pre-requisite	-0.064 **	-0.076	-0.052

Note : a negative sign indicates lower levels of inefficiency.

** Indicates that the confidence interval does not encompass zero, giving an indication of the statistical significance of the estimate.

Table 5. **Efficiency and school-level policies: stochastic frontier analysis**

	Half-normal			Exponential		
	Coefficient		Cluster-robust Z score	Coefficient		Cluster-robust Z score
Constant	5.129	***	49.34	5.087	***	52.78
Teacher-student ratio	0.039		1.40	0.041		1.20
Computer availability	-0.014		-0.65	-0.011		-0.59
Socio-economic background	0.466	***	14.06	0.468	***	17.16
Language background	0.108	***	4.93	0.109	***	5.22
Teacher-student ratio*teacher-student ratio	-0.050	***	-2.82	-0.047	***	-2.70
Computer availability*computer availability	-0.009		-1.84	-0.008	**	-2.08
Teacher-student ratio*computer availability	0.020	**	2.13	0.018	**	2.00
School size (x100)	0.002	**	2.47	0.002	**	2.32
Government-dependent private	0.021	***	2.59	0.022	**	2.27
Independent private	0.001		0.07	0.004		0.23
Teacher qualifications	0.011		1.03	0.013		1.33
Autonomy resources	-0.006	***	-2.67	-0.006	***	-2.59
Autonomy curriculum	0.007		1.55	0.007		1.56
Some streaming	-0.004		-0.86	-0.003		-0.75
Complete streaming	-0.016	**	-2.31	-0.015	**	-2.80
Assessment: medium	-0.001		-0.38	-0.001		-0.38
Assessment: high	-0.012	**	-2.08	-0.013	**	-2.54
Selectivity: considered	0.000		0.02	0.000		0.03
Selectivity: priority	0.022	***	2.82	0.021	***	2.82
Selectivity: pre-requisite	0.046	***	5.48	0.047	***	5.04
Lambda	2.33			1.156		

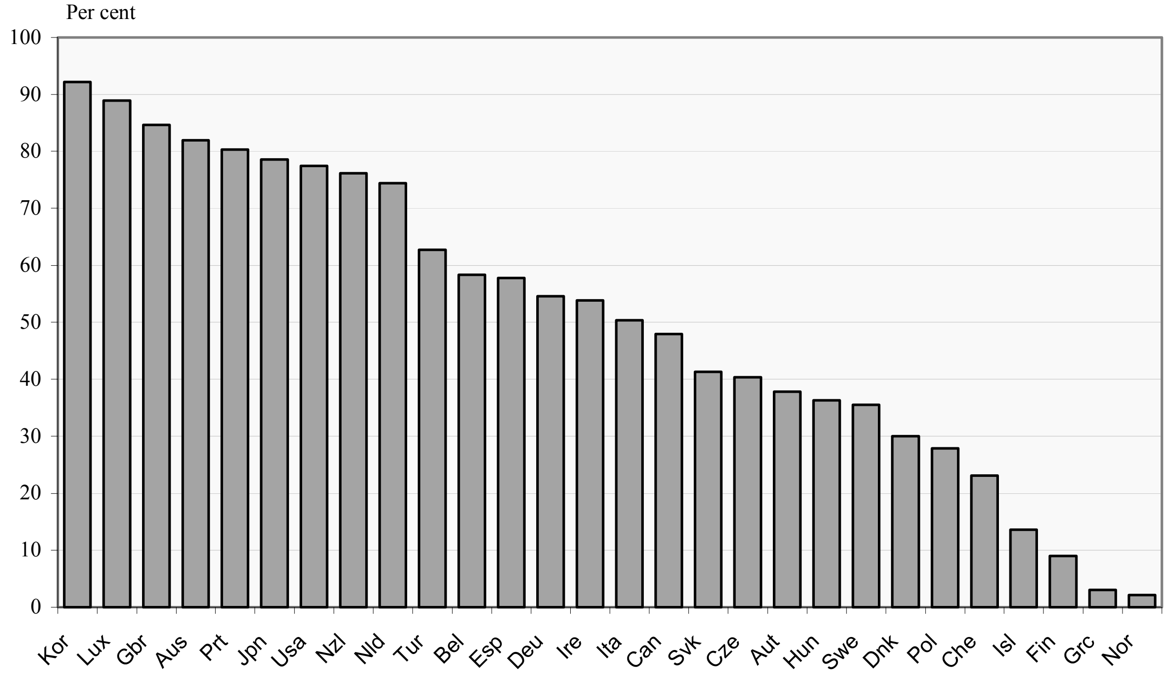
Note : The table presents the estimated coefficients and associated cluster-robust Z-scores for a translog production function. The cluster-robust Z score takes into account the possible lack of independence of school policies within country. ** and *** signify that the estimated coefficient is significantly different from zero at the 5% and 1% level of significance, respectively. A positive coefficient signifies a positive relationship with average performance in PISA tests.

20. The results presented in Sutherland *et al.* (2007) suggested that government-dependent private schools (those privately-owned schools that rely on state funding for the majority of their income) tend to be relatively efficient in the output-maximising direction.[19] The analysis here supports this view, in that levels of technical efficiency measured in the output direction are higher on average in government-dependent private schools, other things being equal, suggesting that a higher ratio of government-

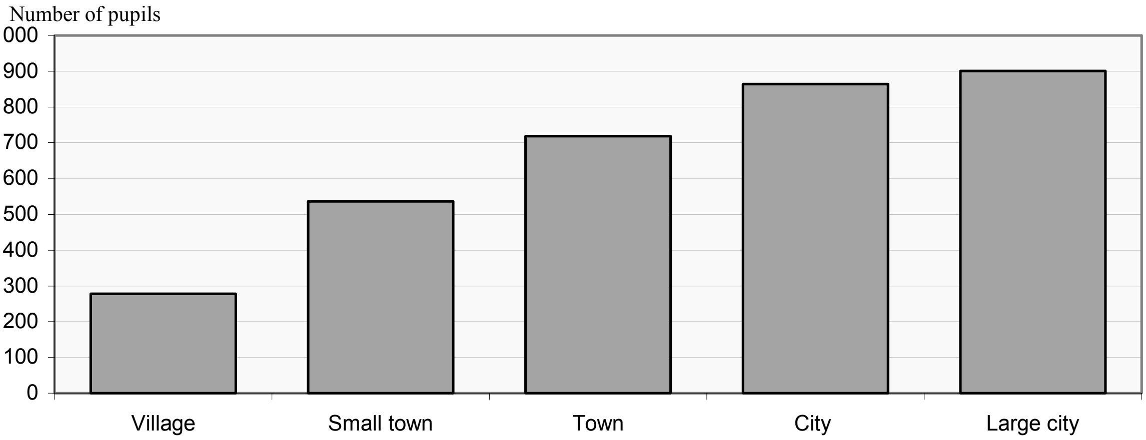
19. Woessmann (2005).

Figure 2. **Relative share of "large" schools**

A. Share of schools larger than median school in the PISA 2003 database



B. Average size of schools by settlement type



Source: PISA 2003 school database

dependent schools could help raise system-wide efficiency. The level of efficiency appears to be sometimes lower in independent private schools when technical efficiency is measured in the input orientation.[20] As Figure 3 suggests, in some countries there may be a case for encouraging a broader range of school types.

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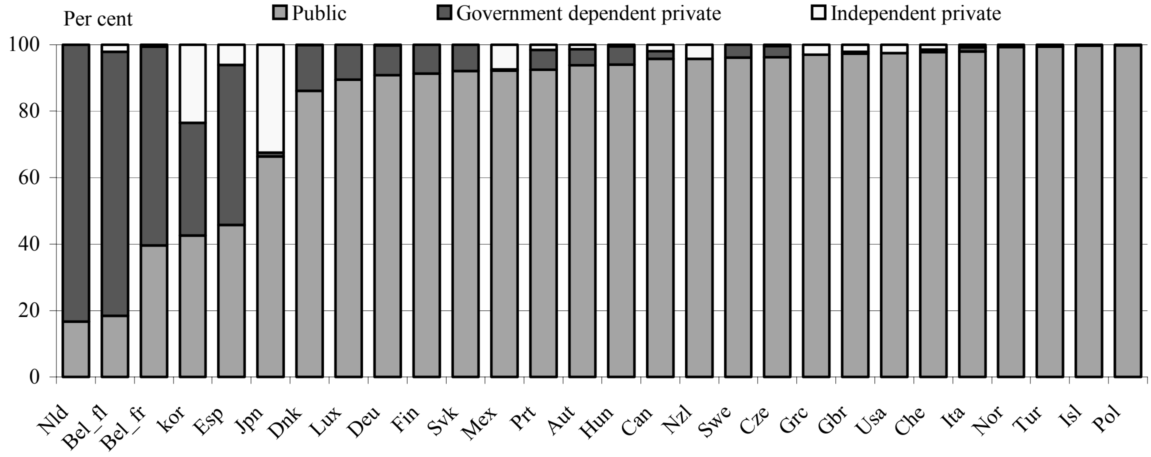
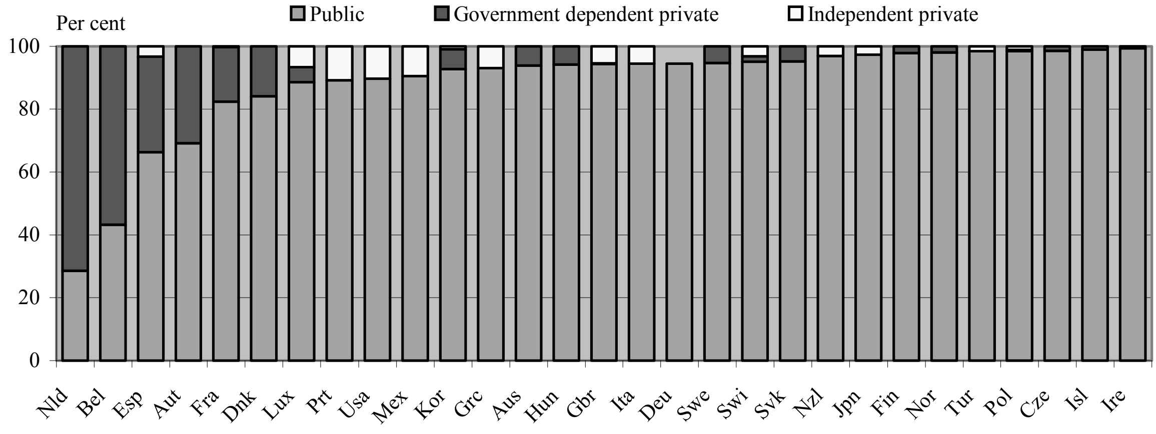
20. Fuchs and Woessmann (2004) note higher levels of student attainment in government-dependent private schools. The coefficient for purely private schools is less robust, being particularly sensitive to the

Figure 3. **Relative importance of different types of schools**

A. Share of students in different school types in PISA 2003 school database



B. Share of primary and lower secondary students according to the type of school they attend, 2003



Source: PISA 2003 school database; Education at a glance, OECD indicators, 2005.

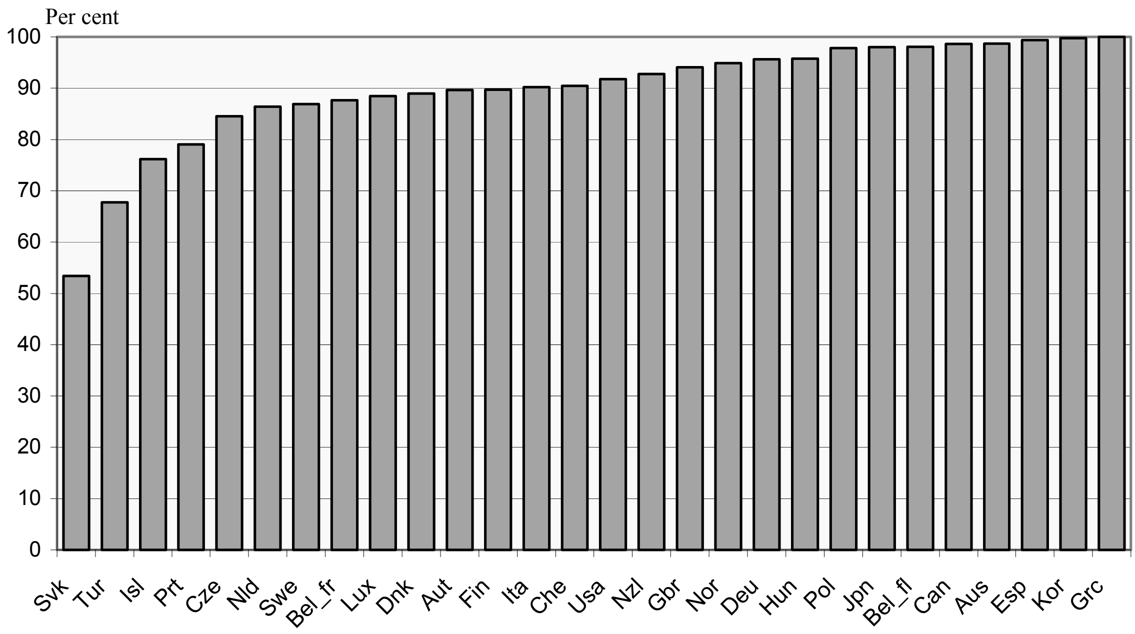
21. Consistent with the findings at the country level, indicators for higher quality teaching resources appear to be correlated with better performance at the school level. The results in Table 4 reveal that the proportion of the teaching staff certified with the national authorities is positively correlated with higher levels of efficiency in the truncated regressions, particularly in the input-saving direction. The estimates coefficients in the stochastic frontier analysis, while also positively related to higher levels of efficiency, are statistically insignificant. If the variable used in the estimation is replaced by the proportion of teachers who possess teaching qualifications the results are very similar (Table A12).[21] Schools also tend to be more efficient when principals report that teaching resources, but not generally the physical infrastructure of the

inclusion of Japanese private schools in the estimation. Estimations omitting Japanese schools from the sample show that independent private schools tend to be more efficient than public schools.

21. The proportion of staff that is certified with the national authorities is used, as a larger number of schools responded to this question. Research focusing on attainment has found limited support for the proposition that teaching qualifications -- the observable proxy for teaching quality -- contribute to higher levels of output (see for example Barrow and Rouse, 2005).

school, are in good order (Tables A13 and A14). As Figure 4 suggests, there appears to be scope for improving the quality of teaching staff in a number of countries, notably Iceland, Portugal, the Slovak Republic and Turkey.[22]

Figure 4. **Average share of certified teachers**



Source: PISA 2003 school database

Resource allocation: decentralisation, matching resources to needs

22. Contrary to the country results, where the devolution of decision-making autonomy to the school level (using the PISA school-level database) was associated with higher levels of efficiency, the measures of decision-making decentralisation derived from the PISA 2003 school-level database paint an inconclusive picture. Although the aggregate indicator for resource autonomy is significant in the output-raising orientation in the truncated regression and the stochastic frontier analysis, estimations for different types of decision-making autonomy were generally insignificant in the truncated regressions.[23] However, the stochastic frontier estimates suggest that student attainment is higher when schools have autonomy over determining teachers' salaries, but not when assessment policies are decentralised to the school level (Table 6).[24]

22. The poor quality of teaching staff was identified as an obstacle in Portugal (Guichard and Larre, 2006).

23. Examination of the individual responses to questions concerning decision-making autonomy in particular domains, such as whether the school can choose its own textbooks, was also inconclusive. These aspects of decision-making were examined using dummy variables that assigned a value of 1 if regional or national authorities had a say in a particular decision.

24. The finding that centralised assessment is conducive to better student attainment is a result noted in other analyses (Fuchs and Woessmann, 2004).

Table 6. **Types of autonomy and performance**
Stochastic frontier analysis

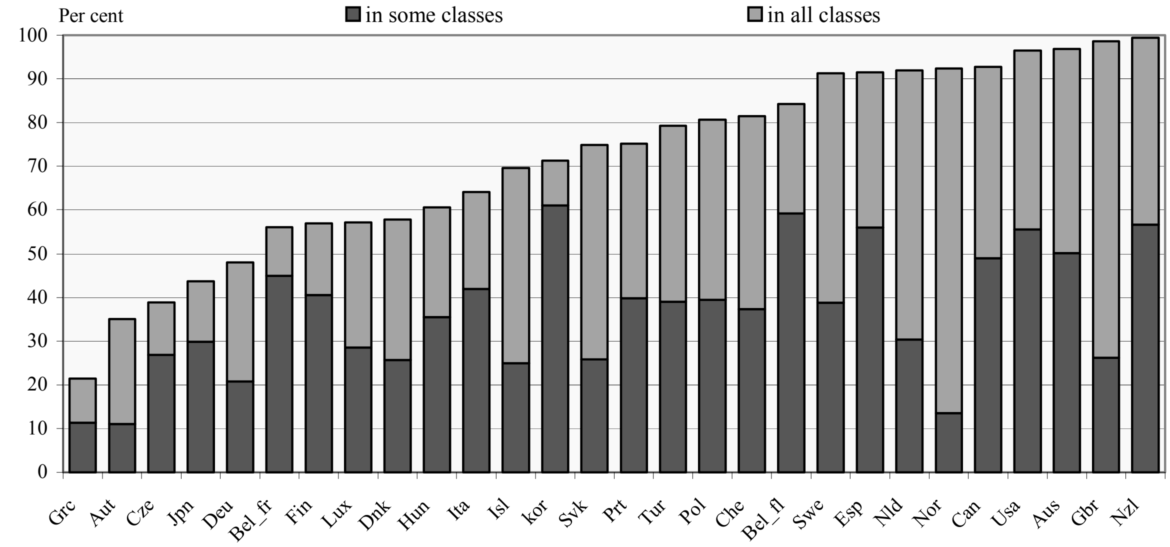
	Coefficient		Cluster-robust Z score	Coefficient		Cluster-robust Z score	Coefficient		Cluster-robust Z score
Constant	5.120	***	51.16	5.114	***	52.97	5.130	***	49.79
Teacher-student ratio	0.038		1.33	0.039		1.35	0.049		1.50
Computer availability	-0.014		-0.65	-0.014		-0.07	-0.013		-0.62
Socio-economic background	0.464	***	13.89	0.465	***	14.76	0.458	***	15.65
Language background	0.118	***	5.83	0.117	***	6.07	0.113	***	5.69
Teacher-student ratio *teacher-student ratio	-0.051	**	-2.56	-0.051	***	-3.13	-0.052	***	-2.74
Computer availability *computer availability	-0.009	**	-2.08	-0.009	**	-2.02	-0.009	***	-2.16
Teacher-student ratio *computer availability	0.022		1.94	0.022	**	2.58	0.021	**	2.14
School size (x100)	0.003	***	2.75	0.003	***	3.27	0.003	***	2.69
Government-dependent private	0.019	**	2.04	0.018	**	2.10	0.016		1.57
Independent private	0.002		0.14	0.003		0.02	-0.004		-0.19
Teacher qualifications	0.010		0.10	0.008		0.89	0.016		1.36
Autonomy over teacher salaries	0.016	**	2.49						
Autonomy over salary increases				0.020	***	3.32			
Autonomy over assessment policies							-0.020	**	-2.01
Some streaming	-0.005		-0.88	-0.005		-0.08	-0.007		-1.30
Complete streaming	-0.018	**	-2.06	-0.017	**	-2.40	-0.021	***	-3.06
Assessment: medium	-0.002		-0.45	-0.002		-0.43	-0.003		-0.69
Assessment: high	-0.011		-1.54	-0.011		-1.75	-0.013	**	-1.96
Selectivity: considered	0.000		0.04	0.000		0.01	-0.001		-0.22
Selectivity: priority	0.022	***	2.81	0.022	***	3.02	0.022	***	2.36
Selectivity: pre-requisite	0.046	***	5.28	0.047	***	4.59	0.440	***	4.57
Lambda	2.306			2.313			2.300		

Note : The table presents the estimated coefficients and associated cluster-robust Z-scores for a translog production function assuming a half-normal distribution. The cluster-robust Z score takes into account the possible lack of independence of school policies within country. ** and *** signify that the estimated coefficient is significantly different from zero at the 5% and 1% level of significance, respectively. A positive coefficient signifies a postive relationship with average performance in PISA tests.

23. The analysis also suggests that schools implementing streaming demonstrate lower levels of technical efficiency in both the input and output orientations, particularly if streaming is for all classes (Table 4).[25] This suggests that there may be opportunities to raise system-wide efficiency by reassessing the extensive use of selection within schools. As can be seen in Figure 5, streaming within schools is most commonly reported in English-speaking countries.[26]

Figure 5. **The prevalence of streaming**

Share of schools in the PISA 2003 database reporting using streaming in some or all classes



Source: PISA 2003 school database

Market framework: benchmarking and user choice

24. The results relating to the frequency of assessment suggest that it has little systematic relation with technical efficiency (Table 4). However, particular types of assessment can be related to efficiency performance (Table 7).[27] The main relationships of these types of assessment with school-level technical efficiency are:

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25. The institutional indicators include information on the age of first selection, which is argued to discriminate against students sorted into the "low" stream or track if selection is too early. The PISA school-level database does not include information on the age at which streaming commences, but there is information on the extent to which it is used within schools. If, however, streaming is implemented by shifting pupils between schools (tracking) this will not be captured.

26. The sorting of students between schools (tracking) may have similar impacts in some cases. Shuetz *et al.* (2005) note *early* tracking heightens the influence of family background on attainment, suggesting that tracking has a negative effect on attainment in the "low track". Estimates of the impact of ability grouping on student attainment, using PISA 2003 data, found that it could vary markedly across countries (Carey and Ernst, 2006), which may be a consequence of associated resource allocation (West and Woessmann (2003).

27. This process uses the same general framework as the baseline regressions, but substitutes the assessment variables by variables that are given a value of one when the school practises a particular type of assessment.

- Assessments made to inform parents appear to be positively correlated with higher levels of technical efficiency measured in the output orientation in the truncated regressions, but not statistically significant in the stochastic frontier estimates. The scope for boosting efficiency here is greatest in Turkey where only four-fifths of schools report using this type of assessment.

- Assessment of pupil progress through the school appears to be correlated with higher levels of efficiency in both the input and output orientations in the truncated regressions. The variable was also statistically significant in some stochastic frontier estimates, though not all.[28]

- Assessment made to group students appears to be negatively correlated with technical efficiency in both the input and output orientation, which is consistent with the finding for streaming reported above. This variable was also statistically significant in some stochastic frontier estimates.

Table 7. **Correlations between assessment type criteria and technical efficiency**
Effect on inefficiency, coefficient estimates from fuller specification

	Coefficient estimate	Confidence intervals derived from pseudo distribution	
		Lower (2.5)	Upper (97.5)
Input orientation			
Assessment to			
inform parents	- 0.017	- 0.045	0.013
assess student progress	- 0.029 **	- 0.044	- 0.013
group students	0.017 **	0.002	0.023
compare nationally	- 0.010	- 0.021	0.002
assess school progress	0.001	- 0.008	0.014
compare to other schools	- 0.010 **	- 0.022	0.000
Ouput orientation			
Assessment to			
inform parents	- 0.021 **	- 0.039	- 0.005
assess student progress	- 0.025 **	- 0.037	- 0.008
group students	0.018 **	0.005	0.021
compare nationally	- 0.011 **	- 0.020	- 0.003
assess school progress	- 0.002	- 0.010	0.008
compare to other schools	- 0.007	- 0.015	0.000

Note : a negative sign indicates lower levels of inefficiency.

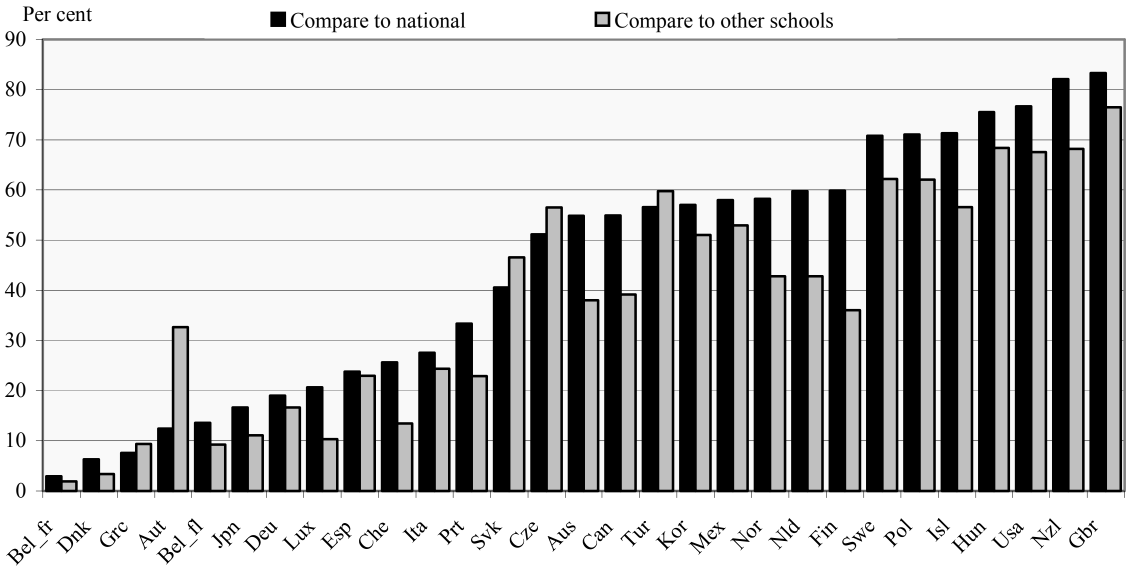
** Indicates that the confidence interval does not encompass zero, giving an indication of the statistical significance of the estimate.

The specification is the same as that given in Table 4, with the individual selection policies sequentially replacing the variables for assessment.

28. However, schools with a higher proportion of students repeating a year tend to be less efficient.

- Assessments may be used both for national comparison and for comparison with other schools, and thus allow for benchmarking.[29] While the results are not robust across all specifications, they suggest that both types of assessment are associated with higher levels of school-level technical efficiency, which is consistent with findings that benchmarking is associated with higher student attainment.[30] As shown in Figure 6, this type of assessment appears to be underdeveloped in Belgium, Denmark and Greece.

Figure 6. **The use of benchmarking in schools**
Share of schools in the PISA 2003 database reporting using assessment
to compare with national performance and other schools



Source: PISA 2003 school database

25. Using an aggregate index of school selectivity already developed in the PISA 2003 database suggests that more demanding selection is associated with higher levels of efficiency (Table 4).[31] When schools report making certain criteria a priority and, more especially, a pre-requisite for selection, levels of

29. Studies on academic attainment frequently highlight the importance of centralised testing systems (Bishop and Woessmann, 2004).

30. The relationship is not statistically significant in all specifications (see Annex), which could be related to features of how benchmarking is designed. If it distorts teaching incentives, benchmarking could lead to “teaching to the test” at the expense of developing other areas of cognitive ability (Lazear, 2006; Jacob, 2007).

31. While for this aggregate indicator the result is the opposite of that expected, this may reflect that competitive pressures may have a greater impact in some schools where selection is strong. Gibbons et al.(2006), using student-level data to investigate attainment in British primary schools, find that competitive pressures driven by greater parental choice have more impact in faith-based schools, which have more freedom in selecting students, than schools in the state system where choice appears to have little effect after accounting for location and pupil sorting. Heckman (2000) and Hoxby (2003) stress the fundamental role competition can play in raising efficiency.

technical efficiency tend to be higher. This finding is subject to two caveats. First, while school selection may be good for schools individually, the aggregate effect in the country as a whole may be detrimental if the outcome is associated with negative externalities in other schools. Second, the type of selection is important as the individual school selection policies can either facilitate or block student or parental choice.[32] To explore this issue, the relationship between school selection policies and school-level technical efficiency is assessed by using the same general framework as the baseline regression, but substituting the selection indicators by variables that are given a value of one when the school practises a particular type of selection (coefficient estimates and confidence intervals are given in Tables 8 and 9). The main results for the different types of selection are.

- Selection based on residence, which limits student (or parental) choice, is negatively related to school-level technical efficiency, particularly in the output orientation. As revealed by Figure 7, residence-based selection criteria are reasonably widespread, with over half the schools in Greece, Poland, Switzerland and the United States reporting that residence is a prerequisite for selection.

- School selection based on academic record, or to a lesser extent recommendations from feeder schools, is related to greater levels of efficiency (amounting to around a 6% improvement for a school with the median level of technical efficiency, other things being equal). This relationship holds if the sample is restricted to just public schools.

Table 8. **Correlations between selection criteria and technical efficiency**
Effect on inefficiency, coefficient estimates from fuller specification

	Coefficient estimate	Confidence intervals derived from pseudo distribution	
		Lower (2.5)	Upper (97.5)
Input orientation			
Selection based on			
Residence	0.013 **	0.001	0.024
Student record	-0.046 **	-0.060	-0.033
Feeder school recommendation	-0.003	-0.020	0.013
Ouput orientation			
Selection based on			
Residence	0.032 **	0.024	0.041
Student record	-0.066 **	-0.076	-0.056
Feeder school recommendation	-0.013 **	-0.025	-0.001

Note : a negative sign indicates lower levels of inefficiency.

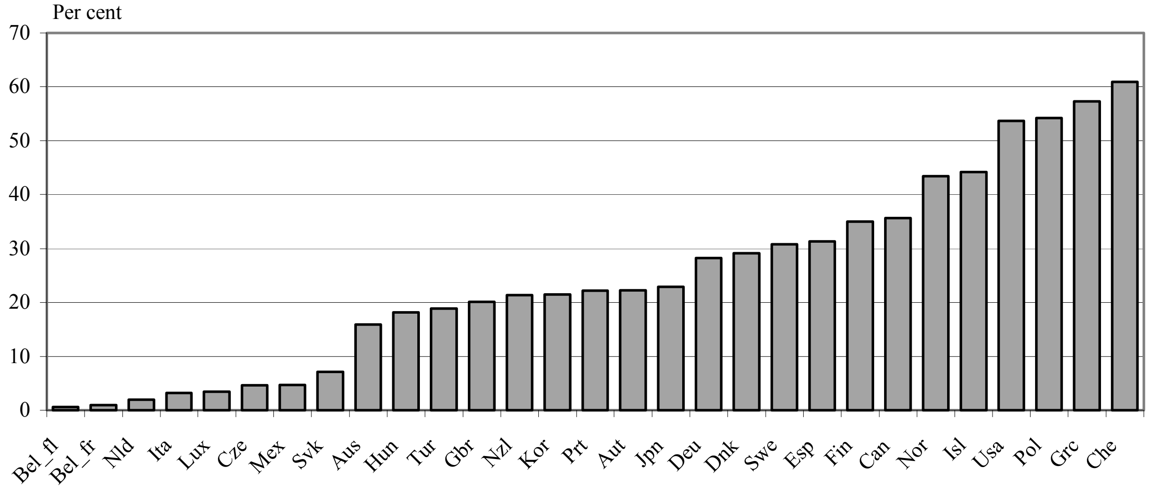
** Indicates that the confidence interval does not encompass zero, giving an indication of the statistical significance of the estimate.

The specification is the same as that given in Table 4, with the individual selection policies sequentially replacing the variables for selectivity.

32. There are other factors -- such as the design of how to implement choice and supporting institutional features -- that can affect whether a greater degree of school choice is effective (Hoxby, 2003).

Figure 7. **Prevalence of residence-based selection criteria**

Share of schools reporting residence as a prerequisite in selection



Source: PISA 2003 school database

Table 9. **Different types of selection criteria and performance**

Stochastic frontier analysis

	Coefficient		Cluster-robust Z score	Coefficient		Cluster-robust Z score	Coefficient		Cluster-robust Z score
Constant	5.106	***	52.48	5.130	***	46.60	5.091	***	40.78
Teacher-student ratio	0.044		1.58	0.038		1.26	0.048		1.55
Computer availability	-0.020		-0.93	-0.015		-0.71	-0.020		-0.87
Socio-economic background	0.485	***	14.85	0.465	***	15.25	0.485	***	13.17
Language background	0.107	***	5.19	0.108	***	5.34	0.113	***	7.14
Teacher-student ratio *teacher-student ratio	-0.062	***	-3.66	-0.051	***	-2.83	-0.060	***	-3.23
Computer availability *computer availability	-0.010		-1.91	-0.009		-1.64	-0.010	**	-2.03
Teacher-student ratio *computer availability	0.026	***	2.83	0.021	**	2.26	0.025	**	2.29
School size (x100)	0.002	***	2.63	0.002	***	2.58	0.002	**	2.55
Government-dependent private	0.019		1.93	0.019	**	2.14	0.023	**	2.08
Independent private	-0.002		-0.12	-0.003		-0.17	0.003		0.17
Teacher qualifications	0.012		1.25	0.011		1.04	0.007		0.56
Autonomy resources	-0.005		-1.81	-0.006	***	-2.64	-0.005	**	-2.17
Autonomy curriculum	0.006		0.93	0.007		1.47	0.007		1.55
Some streaming	-0.008		-1.40	-0.005		-1.17	-0.009		-1.5
Complete streaming	-0.021	***	-2.96	-0.017	***	-2.68	-0.023	**	-3.42
Assessment: medium	-0.003		-0.63	-0.001		-0.33	-0.003		-0.71
Assessment: high	-0.016	**	-2.48	-0.012		-1.83	-0.015	**	-2.35
Selection residence based	-0.016	***	-2.86						
Selection on student record				0.043	***	5.57			
Selection on feeder school recommendation							0.019		1.83
Lambda	2.070			2.304			2.092		

Note: The table presents the estimated coefficients and associated cluster-robust Z-scores for a translog production function assuming a half-normal distribution. The cluster-robust Z score takes into account the possible lack of independence of school policies within country. ** and *** signify that the estimated coefficient is significantly different from zero at the 5% and 1% level of significance, respectively. A positive coefficient signifies a positive relationship with average performance in PISA tests.

BIBLIOGRAPHY

Afonso, A. and M. St. Aubyn (2006), “Cross-country Efficiency of Secondary Education Provision: A Semi-parametric Analysis with Non-discretionary Inputs”, *Economic Modelling*, 23.

Barankay, I. and B. Lockwood (2006), “Decentralization and the Productive Efficiency of Government: Evidence from Swiss Cantons”, *IZA Discussion Paper*, No. 2477.

Barrow, L. and C. Rouse (2005), “Causality, Causality, Causality; the View of Education Inputs and Outputs from Economics”, *Federal Reserve Bank of Chicago*, *Working Paper* 2005-15.

Bishop, J. and L. Woessmann (2004), “Institutional Effects in a Simple Model of Educational Production”, *Education Economics*, 12.

Carey, D. and E. Ernst (2006), “Improving Education Achievement and Attainment in Luxembourg”, *OECD Economics Department Working Papers*, No. 508, OECD, Paris.

Fuchs, T. and L. Woessmann (2004), “What Accounts for International Differences in Student Performance? A Re-examination using PISA Data”, *Empirical Economics*.

Gibbons, S., S. Machin, and O. Silva (2006), “Choice, Competition and Pupil Achievement”, *IZA Discussion Paper*, No. 2214.

Gonand, F., R. Price and I. Joumard (2007), "Public Spending Efficiency: Institutional Indicators in Primary and Secondary Education" *OECD Economics Department Working Papers* No. 543, OECD, Paris.

Guichard, S. and B. Larre (2006), “Enhancing Portugal’s Human Capital”, *OECD Economics Department Working Papers*, No. 505, OECD, Paris.

Hanushek, E. (1996), “School Resources and Student Performance” in G. Burtless, (ed.) *Does Money Matter? The Effect of School Resources on Student Achievement and Adult Success*, Brookings Institution Press, Washington DC, pp. 43-73.

Heckman, J. (2000), “Policies to Foster Human Capital”, *Research in Economics*, 54.

Hoxby, C. (2003), “School Choice and School Competition: Evidence from the United States”, *Swedish Economic Policy Paper*, 10.

Jacob, B. (2007), “Test-based Accountability and Student Achievement: An Investigation of Differential Performance on NAEP and State Assessments”, *NBER Working Paper*, No. 12817.

Lazear, E. (2006), “Speeding, Terrorism, and Teaching to the Test”, *Quarterly Journal of Economics*, August.

Maddala, G. (1983), *Limited-Dependent and Qualitative Variables in Econometrics*, Cambridge Univerity Press.

OECD (2004), *Education at a Glance*, OECD, Paris.

Shuetz, G., H. Ursprung and L. Woessmann (2005), "Education Policy and Equality of Opportunity", *mimeo*.

Simar, L. and P. Wilson (2007), "Estimation and Inference in Two-stage, Semi-parametric Models of Production Processes", *Journal of Econometrics*, 136.

Sutherland, D., R. Price, I. Joumard and C. Nicq (2007), "Performance Indicators for Public Spending Efficiency in Primary and Secondary Education" *OECD Economics Department Working Papers*, No. 546, OECD, Paris.

West, M. and L. Woessmann (2003), "Which School Systems Sort Weaker Students into Smaller Classes? International Evidence", *mimeo*.

Woessmann, L. (2005), "Public-Private Partnerships in Schooling: Cross-Country Evidence on their Effectiveness in Providing Cognitive Skills", *mimeo*.

Zelenuyk, V. (2005), "Power of Significance Test of Dummies in Simar-Wilson Two-Stage Efficiency Analysis Model" *Université Catholique de Louvain, Institut de Statistique Discussion Paper*, No. 0522.

ANNEX: DATA AND SUPPLEMENTARY RESULTS

Table A1. **DEA estimates of technical efficiency at the school level**

Preferred specification[1]

	Input efficiency		Output efficiency	
	Median	Range 90%	Median	Range 90%
Australia	1.42	0.15	1.26	0.14
Austria	1.50	0.26	1.30	0.26
Belgium	1.46	0.32	1.23	0.28
Belgium Flemish c.	1.44	0.22	1.21	0.22
Belgium French c.	1.50	0.41	1.28	0.38
Canada	1.43	0.20	1.29	0.19
Czech Republic	1.40	0.18	1.26	0.24
Denmark	1.53	0.18	1.31	0.13
Finland	1.43	0.13	1.22	0.11
Germany	1.35	0.19	1.25	0.23
Greece	1.59	0.25	1.37	0.25
Hungary	1.55	0.26	1.32	0.29
Iceland	1.63	0.16	1.36	0.15
Ireland	1.39	0.17	1.25	0.13
Italy	1.53	0.30	1.27	0.28
Japan	1.36	0.30	1.20	0.28
Korea	1.28	0.21	1.17	0.20
Luxembourg	1.56	0.16	1.35	0.13
Netherlands	1.35	0.22	1.26	0.21
New Zealand	1.37	0.19	1.26	0.17
Norway	1.67	0.12	1.38	0.15
Poland	1.40	0.18	1.24	0.17
Portugal	1.46	0.22	1.26	0.22
Slovak Republic	1.40	0.20	1.25	0.23
Spain	1.44	0.23	1.27	0.20
Sweden	1.47	0.13	1.30	0.12
Switzerland	1.41	0.23	1.27	0.23
Turkey	1.39	0.28	1.31	0.30
United Kingdom	1.43	0.17	1.27	0.18
United States	1.54	0.19	1.35	0.20
Standard deviation	0.09	0.06	0.05	0.06
Median	1.44	0.20	1.27	0.21
Average	1.46	0.21	1.28	0.21

1. PISA score as output and teachers student ratio, computer availability, socio-economic and language backgrounds as inputs.

Table A2. **DEA estimates of technical efficiency at the national level**

Preferred specification[1]

	Input efficiency			Output efficiency		
	VRS	NIRS	CST RTS	VRS	NIRS	CST RTS
Australia	1.15	1.17	1.16	1.05	1.05	1.16
Austria	1.12	1.13	1.13	1.07	1.07	1.13
Belgium Flemish c.	1.15	1.16	1.12	1.02	1.02	1.12
Belgium French c.	1.14	1.17	1.17	1.11	1.11	1.18
Canada	1.24	1.25	1.24	1.04	1.04	1.25
Czech Republic	1.14	1.15	1.15	1.06	1.06	1.15
Denmark	1.17	1.17	1.16	1.05	1.05	1.16
Finland	1.08	1.09	1.11	1.02	1.02	1.11
France	1.06	1.07	1.07	1.06	1.06	1.07
Germany	1.13	1.19	1.19	1.10	1.10	1.19
Greece	1.07	1.10	1.10	1.08	1.07	1.10
Hungary	1.08	1.09	1.08	1.05	1.05	1.08
Iceland	1.33	1.33	1.32	1.05	1.05	1.32
Ireland	1.06	1.06	1.05	1.03	1.03	1.05
Italy	1.08	1.11	1.11	1.08	1.08	1.11
Japan	1.05	1.07	1.05	1.04	1.04	1.05
Korea	1.08	1.10	1.09	1.04	1.04	1.12
Luxembourg	1.18	1.18	1.18	1.07	1.07	1.18
Netherlands	1.11	1.13	1.13	1.06	1.06	1.13
New Zealand	1.15	1.17	1.17	1.05	1.05	1.17
Norway	1.30	1.32	1.32	1.08	1.08	1.33
Poland	1.04	1.04	1.04	1.04	1.04	1.04
Slovak Republic	1.06	1.08	1.08	1.06	1.06	1.08
Spain	1.03	1.02	1.02	1.04	1.03	1.02
Sweden	1.17	1.18	1.18	1.06	1.06	1.18
Switzerland	1.06	1.08	1.07	1.06	1.06	1.07
United Kingdom	1.12	1.16	1.16	1.07	1.07	1.17
United States	1.17	1.23	1.23	1.09	1.09	1.23
Standard deviation	0.07	0.08	0.08	0.02	0.02	0.08
Median	1.12	1.14	1.13	1.06	1.06	1.13
Average	1.12	1.14	1.13	1.06	1.06	1.14

Note : VRS = variable returns to scale; NIRS = non-increasing returns to scale; CST RTS = constant returns to scale.

1. Bootstrap estimates with 2 inputs (teachers per 100 students and socio-economic background) and 2 outputs (average PISA score and homogeneity of PISA score).

Table A3. **DEA estimates of cost efficiency at the national level**

Preferred specification[1]

	Input efficiency			Output efficiency		
	VRS	NIRS	CST RTS	VRS	NIRS	CST RTS
Australia	1.19	1.19	1.25	1.05	1.05	1.26
Austria	1.18	1.18	1.26	1.06	1.06	1.26
Belgium-Flemish	1.17	1.17	1.20	1.02	1.02	1.21
Belgium French	1.22	1.22	1.29	1.11	1.11	1.29
Czech Republic	1.18	1.18	1.32	1.05	1.05	1.33
Denmark	1.25	1.25	1.31	1.05	1.05	1.32
Finland	1.11	1.11	1.21	1.02	1.02	1.21
France	1.10	1.10	1.18	1.06	1.06	1.18
Germany	1.21	1.21	1.28	1.10	1.10	1.29
Greece	1.25	1.25	1.32	1.08	1.08	1.34
Hungary[2]	1.17	1.17	1.31	1.03	1.03	1.34
Iceland	1.43	1.43	1.50	1.05	1.05	1.51
Ireland	1.12	1.12	1.22	1.03	1.03	1.23
Italy[2]	1.22	1.22	1.30	1.08	1.08	1.30
Japan	1.07	1.07	1.13	1.04	1.04	1.13
Korea	1.11	1.11	1.12	1.04	1.04	1.13
Luxembourg[2]	1.29	1.29	1.37	1.08	1.08	1.37
Mexico	1.11	1.11	1.16	1.04	1.04	1.24
Netherlands	1.14	1.14	1.21	1.05	1.05	1.21
New Zealand	1.20	1.20	1.26	1.05	1.05	1.27
Norway	1.39	1.39	1.48	1.08	1.08	1.49
Poland[2]	1.08	1.08	1.31	1.02	1.02	1.36
Portugal[2]	1.06	1.06	1.14	1.02	1.02	1.15
Slovak Republic	1.10	1.10	1.13	1.04	1.04	1.16
Spain	1.11	1.11	1.18	1.04	1.04	1.18
Sweden	1.22	1.22	1.30	1.06	1.06	1.30
Switzerland[2]	1.12	1.12	1.19	1.06	1.06	1.19
United Kingdom	1.18	1.18	1.25	1.06	1.06	1.26
United States	1.30	1.30	1.38	1.09	1.09	1.38
Standard deviation	0.09	0.09	0.10	0.02	0.02	0.10
Median	1.18	1.18	1.26	1.05	1.05	1.26
Average	1.18	1.18	1.25	1.05	1.05	1.27

Note: VRS = variable returns to scale; NIRS = non-increasing returns to scale; CST RTS = constant returns to scale.

1. Bootstrap estimates with 2 inputs (cumulative expenditure per student and socio-economic background) and 2 outputs (average PISA score and homogeneity of PISA score).

2. Public institutions only.

Table A4. **Composite insitutional indicators**

	USA	JPN	DEU	FRA	GBR	ITA	CAN	AUS	AUT	BEL (Fl.)	BEL (F.)	CHE	CZE	DNK	ESP	FIN	GRE	HUN	ISL	LUX	MEX	NLD	NOR	NZL	PRT	SVK	SWE	TUR	OECD average	OECD best practice
Intermediate indicators[1]																														
Decentralisation	5.9	5.6	8.0	4.1	5.0	5.0	8.3	7.4	3.5	8.7	6.2	8.4	3.3	9.6	8.4	9.3	6.1	6.3	8.7	3.7	7.2	4.1	7.1	7.2	3.4	2.9	8.4	4.5	**6.3**	**9.6**
Matching resources to specific needs	6.7	7.0	2.3	7.5	6.7	6.8	3.7	5.8	0.8	4.7	5.5	5.0	5.7	6.7	6.7	6.7	3.3	4.0	6.7	2.0	5.5	6.3	6.7	7.5	8.3	2.3	6.7	0.7	**5.3**	**8.3**
Outcome focused policy	6.0	0.5	2.9	3.3	5.4	0.0	1.8	2.6	2.5	2.9	2.1	0.8	2.5	0.4	0.7	2.3	3.5	0.8	0.0	0.1	7.0	3.9	0.6	3.4	1.7	7.9	4.6	6.4	**2.7**	**7.9**
Managerial autonomy	5.8	5.8	5.5	3.8	7.7	4.0	5.9	6.4	4.5	4.0	4.6	2.1	6.4	5.5	4.7	4.9	2.7	7.0	2.2	1.6	1.4	5.7	6.5	6.4	5.3	6.8	5.2	3.3	**4.8**	**7.7**
Benchmarking	5.8	2.2	2.3	5.0	9.0	7.3	6.6	6.6	0.8	0.4	1.8	0.6	1.8	6.0	2.3	1.5	6.7	9.4	8.7	5.5	1.8	8.5	6.8	4.3	5.9	7.4	7.3	6.1	**4.9**	**9.4**
User choice	4.0	3.8	4.4	2.8	5.2	5.1	3.9	6.4	3.5	8.5	9.5	3.8	4.1	6.1	8.0	4.1	3.0	4.0	7.0	5.2	3.7	8.0	5.8	4.4	5.4	4.9	4.2	2.4	**5.0**	**9.5**
Efficiency types[2]																														
with multiplicative aggregation																														
Quality in resource allocation	6.2	5.2	3.3	6.0	6.7	6.4	5.6	6.4	1.3	3.3	4.4	3.6	4.0	7.1	5.5	5.2	4.9	5.8	7.7	3.3	4.5	6.1	6.8	6.5	6.4	3.5	7.2	3.0	**5.2**	**7.7**
Quality in budget management	5.9	1.8	3.6	3.8	6.8	0.4	3.7	4.4	2.8	2.5	2.8	1.2	3.5	1.9	1.8	3.0	3.5	3.0	0.4	0.6	2.8	5.2	2.5	4.6	3.4	7.4	5.2	4.8	**3.3**	**7.4**
Market framework	5.3	2.5	2.7	4.4	7.9	6.7	5.9	6.5	1.3	1.1	2.9	1.0	2.2	6.0	3.2	2.0	5.6	7.7	8.3	5.5	2.2	8.4	6.6	4.4	5.8	6.7	6.4	5.0	**4.8**	**8.4**
with exponential aggregation and low degree of complementarity[3]																														
Quality in resource allocation	6.2	6.1	4.9	5.8	5.9	5.9	5.8	6.5	1.9	6.4	5.6	6.4	4.3	7.9	7.3	7.7	4.7	5.1	7.7	2.8	6.1	5.2	6.8	7.1	5.9	2.6	7.3	2.6	**5.7**	**7.9**
Quality in budget management	5.8	2.9	3.8	3.5	6.3	1.7	3.6	4.2	3.1	3.0	3.0	1.2	4.1	2.7	2.4	3.2	2.9	3.6	0.9	0.6	3.9	4.6	3.3	4.6	3.3	7.2	4.8	4.6	**3.5**	**7.2**
Market framework	4.9	2.7	3.1	3.9	7.1	6.2	5.3	6.5	1.9	4.2	5.4	1.9	2.7	6.0	4.9	2.6	4.8	6.7	7.9	5.4	2.5	8.3	6.3	4.4	5.7	6.2	5.8	4.3	**4.9**	**8.3**
with exponential aggregation and high degree of complementarity[4]																														
Quality in resource allocation	6.2	4.8	2.6	5.8	5.9	5.9	5.4	6.4	1.1	2.8	3.9	3.0	3.9	6.6	4.7	4.3	4.7	5.1	7.7	2.8	3.9	5.2	6.8	6.2	5.9	2.6	7.2	2.6	**4.8**	**7.7**
Quality in budget management	5.8	0.8	2.9	3.4	5.6	0.3	2.0	2.8	2.1	2.1	2.2	1.0	2.5	0.6	0.9	2.3	2.8	1.0	0.2	0.3	1.6	4.1	0.9	3.6	2.0	7.0	4.7	3.5	**2.5**	**7.0**
Market framework	4.9	2.4	2.5	3.9	7.1	6.2	5.3	6.5	1.1	0.7	2.0	0.8	2.0	6.0	2.5	1.8	4.8	6.7	7.9	5.4	2.0	8.3	6.3	4.4	5.7	6.2	5.8	4.3	**4.4**	**8.3**
Composite indicators																														
with multiplicative aggregation	5.8	3.2	3.2	4.7	7.1	4.5	5.0	5.8	1.8	2.3	3.4	1.9	3.3	5.0	3.5	3.4	4.6	5.5	5.5	3.1	3.2	6.6	5.3	5.2	5.2	5.8	6.3	4.2	**4.4**	**7.1**
with exponential aggregation and low degree of complementarity[3]	5.1	4.6	4.6	5.7	6.4	5.5	5.5	5.4	4.8	3.9	3.9	6.0	5.7	4.5	3.2	3.8	4.9	4.1	5.9	4.6	2.9	3.7	5.3	4.2	4.7	5.5	2.3	4.4	**4.7**	**6.4**
with exponential aggregation and high degree of complementarity[4]	5.6	2.7	2.7	4.4	6.2	4.1	4.2	5.2	1.4	1.8	2.7	1.6	2.8	4.4	2.7	2.8	4.1	4.3	5.3	2.8	2.5	5.9	4.7	4.7	4.5	5.3	5.9	3.4	**3.9**	**6.2**

1. Scores for intermediate indicators before transformation taking account of complementarities (see Annex 2).
2. The score for each efficiency type is computed as a non-weighted average of its associated intermediate indicators after transformation of their values according to the methods detailed in Annex 2.
3. The value of gamma is set at 0.2 (see Annex 2).
4. The value of gamma is set at 0.8 (see Annex 2).

Source: Gonand *et al*. (2007).

Table A5. **Indicators of the extent of decentralisation**

Percentage of decisions taken at the level of the school

		Regarding			
	Total	Instruction	Personnel	Planning	Resources
Australia	24	88	0	10	0
Austria	29	88	0	10	17
Belgium-Flemish					
Belgium-French	43	63	17	43	50
Canada					
Czech Republic	60	88	75	50	29
Denmark	44	88	42	0	46
Finland	27	88	21	0	0
France	31	75	13	21	17
Germany	32	88	8	14	17
Greece	13	50	0	0	0
Hungary	68	100	67	71	33
Iceland	25	63	38	0	0
Ireland					
Italy	46	100	33	36	17
Japan	23	63	0	30	0
Korea	48	75	42	25	50
Luxembourg	34	63	13	29	33
Mexico	22	75	0	14	0
Netherlands	100	100	100	100	100
New Zealand	75	100	79	60	63
Norway	37	71	42	0	33
Poland					
Portugal	41	75	33	7	50
Slovak Republic	50	88	50	29	33
Spain	28	88	8	0	17
Sweden	47	88	67	0	33
Switzerland					
Turkey	24	63	0	33	0
United Kingdom	85	100	83	57	100
United States					

Source : OECD (2004), *Education at a Glance* .

Table A6. **School-level data from the PISA 2003 questionnaire**

	Number	Mean	Standard deviation	Maximum	Minimum
School size	6204	654.9	477.3	6000	4
Teachers are:					
Certified	5458	0.9	0.2	1	0
Qualified	4543	0.7	0.4	1	0
Autonomy					
Total	6191	0.1	0.9	1.7	-2.8
Resource	6191	3.4	1.8	6.0	0.0
Curricular	6187	3.2	1.2	4.0	0.0

Table A7. **Institutional indicators and technical efficiency of the median school**

Coefficient estimates from correlations between technical efficiency estimates and institutional indicators

	Non-increasing returns to scale			Variable returns to scale			Constant returns to scale		
	Coefficient estimate	A		Coefficient estimate	A		Coefficient estimate	A	
		Lower (2.5)	Upper (97.5)		Lower (2.5)	Upper (97.5)		Lower (2.5)	Upper (97.5)
Efficiency measured in the input orientation									
Resource allocation									
Multiplicative weighting	0.015	-0.002	0.033	0.015	-0.004	0.033	0.012	-0.006	0.030
Exponential weighting (low)	0.016	-0.005	0.036	0.015	-0.004	0.036	0.013	-0.007	0.031
Exponential weighting (high)	**0.018**	**0.001**	**0.035**	0.018	0.000	0.035	0.014	-0.002	0.031
Budget management									
Multiplicative weighting	**-0.021**	**-0.036**	**-0.006**	**-0.021**	**-0.036**	**-0.005**	**-0.020**	**-0.034**	**-0.006**
Exponential weighting (low)	**-0.028**	**-0.046**	**-0.011**	**-0.028**	**-0.046**	**-0.010**	**-0.027**	**-0.043**	**-0.011**
Exponential weighting (high)	**-0.021**	**-0.036**	**-0.007**	**-0.021**	**-0.036**	**-0.006**	**-0.020**	**-0.034**	**-0.006**
Market framework									
Multiplicative weighting	0.007	-0.007	0.021	0.007	-0.007	0.020	0.005	-0.008	0.019
Exponential weighting (low)	0.009	-0.009	0.025	0.008	-0.010	0.025	0.007	-0.009	0.024
Exponential weighting (high)	0.006	-0.008	0.019	0.006	-0.009	0.019	0.004	-0.009	0.018
Efficiency measured in the output orientation									
Resource allocation									
Multiplicative weighting	0.009	-0.001	0.020	0.009	-0.002	0.020	0.010	-0.009	0.028
Exponential weighting (low)	0.004	-0.008	0.016	0.004	-0.009	0.016	0.009	-0.012	0.030
Exponential weighting (high)	0.011	0.001	0.020	**0.011**	**0.001**	**0.021**	0.013	-0.004	0.030
Budget management									
Multiplicative weighting	-0.003	-0.013	0.007	-0.003	-0.013	0.007	**-0.019**	**-0.033**	**-0.004**
Exponential weighting (low)	-0.006	-0.019	0.006	-0.006	-0.019	0.006	**-0.026**	**-0.043**	**-0.008**
Exponential weighting (high)	-0.004	-0.014	0.006	-0.003	-0.014	0.006	**-0.017**	**-0.034**	**-0.005**
Market framework									
Multiplicative weighting	0.007	-0.001	0.015	0.007	-0.001	0.015	0.005	-0.008	0.019
Exponential weighting (low)	0.007	-0.004	0.017	0.007	-0.004	0.017	0.007	-0.011	0.024
Exponential weighting (high)	0.007	-0.001	0.014	0.007	-0.001	0.015	0.004	-0.009	0.018

Note: A stands for confidence intervals derived from pseudo distribution. Estimates are bolded if the confidence interval does not include zero.

Table A8. **Institutional indicators and country-level technical efficiency**

Coefficient estimates from correlations between technical efficiency estimates and institutional indicators

	Non-increasing returns to scale			Variable returns to scale			Constant returns to scale		
	Coefficient estimate	A		Coefficient estimate	A		Coefficient estimate	A	
		Lower (2.5)	Upper (97.5)		Lower (2.5)	Upper (97.5)		Lower (2.5)	Upper (97.5)
Efficiency measured in the input orientation									
Resource allocation									
Multiplicative weighting	0.016	-0.003	0.040	0.016	-0.004	0.038	0.016	-0.004	0.036
Exponential weighting (low)	0.019	-0.002	0.042	0.019	-0.003	0.041	0.019	-0.001	0.040
Exponential weighting (high)	**0.019**	**0.001**	**0.038**	0.019	0.001	0.038	**0.018**	**0.000**	**0.037**
Budget management									
Multiplicative weighting	-0.007	-0.026	0.011	-0.007	-0.026	0.012	-0.005	-0.024	0.014
Exponential weighting (low)	-0.009	-0.031	0.014	-0.009	-0.031	0.014	-0.006	-0.028	0.016
Exponential weighting (high)	-0.006	-0.025	0.012	-0.006	-0.024	0.012	-0.004	-0.022	0.014
Market framework									
Multiplicative weighting	0.009	-0.006	0.023	0.009	-0.007	0.024	0.007	-0.008	0.022
Exponential weighting (low)	0.013	-0.006	0.032	0.013	-0.007	0.032	0.008	-0.010	0.027
Exponential weighting (high)	0.009	-0.006	0.024	0.009	-0.005	0.024	0.007	-0.007	0.022
Efficiency measured in the output orientation									
Resource allocation									
Multiplicative weighting	-0.001	-0.007	0.005	-0.002	-0.007	0.005	0.016	-0.005	0.037
Exponential weighting (low)	-0.004	-0.011	0.002	-0.004	-0.010	0.002	0.018	-0.003	0.041
Exponential weighting (high)	-0.001	-0.006	0.005	-0.001	-0.006	0.005	0.019	-0.001	0.038
Budget management									
Multiplicative weighting	0.002	-0.003	0.007	0.002	-0.003	0.007	-0.003	-0.022	0.016
Exponential weighting (low)	0.002	-0.004	0.008	0.002	-0.004	0.008	-0.003	-0.026	0.020
Exponential weighting (high)	0.002	-0.003	0.008	0.002	-0.002	0.008	-0.002	-0.021	0.017
Market framework									
Multiplicative weighting	0.001	-0.003	0.005	0.001	-0.004	0.005	0.008	-0.008	0.022
Exponential weighting (low)	0.000	-0.005	0.005	0.000	-0.005	0.006	0.009	-0.011	0.029
Exponential weighting (high)	0.000	-0.004	0.005	0.000	-0.004	0.005	0.009	-0.006	0.025

Note: A stands for confidence intervals derived from pseudo distribution. Estimates are bolded if the confidence interval does not include zero.

Table A9. **Institutional indicators and country-level cost efficiency**

Coefficient estimates from correlations between cost efficiency estimates and institutional indicators

	Non-increasing returns to scale			Variable returns to scale			Constant returns to scale		
	Coefficient estimate	A		Coefficient estimate	A		Coefficient estimate	A	
		Lower (2.5)	Upper (97.5)		Lower (2.5)	Upper (97.5)		Lower (2.5)	Upper (97.5)
Efficiency measured in the input orientation									
Resource allocation									
Multiplicative weighting	0.020	-0.002	0.044	0.020	-0.002	0.042	0.020	0.000	0.042
Exponential weighting (low)	**0.024**	**0.002**	**0.049**	**0.024**	**0.002**	**0.047**	**0.022**	**0.001**	**0.044**
Exponential weighting (high)	**0.002**	**0.006**	**0.045**	**0.023**	**0.004**	**0.045**	**0.023**	**0.004**	**0.042**
Budget management									
Multiplicative weighting	-0.014	-0.032	0.005	-0.014	-0.033	0.003	-0.016	-0.034	0.002
Exponential weighting (low)	-0.018	-0.042	0.005	-0.018	-0.041	0.003	-0.020	-0.042	0.003
Exponential weighting (high)	-0.013	-0.033	0.004	-0.013	-0.032	0.005	-0.017	-0.035	0.002
Market framework									
Multiplicative weighting	0.009	-0.006	0.026	0.009	-0.006	0.025	0.008	-0.006	0.024
Exponential weighting (low)	0.013	-0.005	0.034	0.013	-0.007	0.035	0.010	-0.011	0.029
Exponential weighting (high)	0.010	-0.006	0.025	0.010	-0.005	0.026	0.009	-0.007	0.024
Efficiency measured in the output orientation									
Resource allocation									
Multiplicative weighting	-0.001	-0.007	0.006	-0.001	-0.007	0.006	0.019	-0.001	0.040
Exponential weighting (low)	-0.002	-0.009	0.004	-0.002	-0.010	0.005	0.020	-0.003	0.041
Exponential weighting (high)	0.000	-0.006	0.007	0.000	-0.006	0.007	**0.022**	**0.003**	**0.041**
Budget management									
Multiplicative weighting	0.000	-0.006	0.006	0.000	-0.005	0.006	-0.014	-0.033	0.004
Exponential weighting (low)	0.000	-0.007	0.007	0.000	-0.007	0.007	-0.017	-0.039	0.005
Exponential weighting (high)	0.002	-0.004	0.007	0.002	-0.004	0.008	-0.016	-0.033	0.003
Market framework									
Multiplicative weighting	0.000	-0.004	0.005	0.000	-0.004	0.005	0.010	-0.006	0.024
Exponential weighting (low)	0.000	-0.006	0.006	0.000	-0.006	0.006	0.011	-0.009	0.031
Exponential weighting (high)	0.000	-0.005	0.005	0.000	-0.005	0.005	0.010	-0.005	0.025

Note: A stands for confidence intervals derived from pseudo distribution. Estimates are bolded if the confidence interval does not include zero.

Table A10. **Correlations between combined institutional indicators and technical efficiency of the median school**
Coefficient estimates from correlations between technical efficiency estimates and institutional indicators

	Non-increasing returns to scale			Variable returns to scale			Constant returns to scale		
	Coefficient estimate	A		Coefficient estimate	A		Coefficient estimate	A	
		Lower (2.5)	Upper (97.5)		Lower (2.5)	Upper (97.5)		Lower (2.5)	Upper (97.5)
Input orientation									
Resource allocation	0.006	-0.019	0.032	0.005	-0.020	0.030	0.000	-0.023	0.024
Budget management	**-0.024**	**-0.038**	**-0.008**	**-0.024**	**-0.039**	**-0.008**	**-0.023**	**-0.037**	**-0.009**
Market framework	0.009	-0.010	0.027	0.009	-0.010	0.028	0.010	-0.007	0.027
Relative teachers' renumeration	**-0.128**	**-0.206**	**-0.049**	**-0.130**	**-0.206**	**-0.049**	**-0.140**	**-0.216**	**-0.070**
Resource allocation	0.003	-0.015	0.022	0.002	-0.017	0.022	0.000	-0.019	0.018
Budget management	**-0.029**	**-0.046**	**-0.010**	**-0.029**	**-0.047**	**-0.010**	**-0.029**	**-0.046**	**-0.011**
Market framework	0.011	-0.005	0.027	0.011	-0.006	0.027	0.011	-0.005	0.026
Relative teachers' renumeration	**-0.146**	**-0.225**	**-0.069**	**-0.149**	**-0.226**	**-0.070**	**-0.016**	**-0.232**	**-0.084**
Resource allocation	0.015	-0.006	0.037	0.015	-0.008	0.037	0.010	-0.012	0.030
Budget management	**-0.020**	**-0.034**	**-0.006**	**-0.020**	**-0.034**	**-0.005**	**-0.019**	**-0.033**	**-0.005**
Market framework	0.000	-0.016	0.016	0.000	-0.016	0.017	0.001	-0.014	0.018
Relative teachers' renumeration	**-0.146**	**-0.217**	**-0.074**	**-0.149**	**-0.223**	**-0.076**	**-0.016**	**-0.231**	**-0.091**
Output orientation									
Resource allocation	0.000	-0.016	0.016	0.000	-0.016	0.018	-0.004	-0.279	0.021
Budget management	-0.006	-0.016	0.004	-0.006	-0.016	0.004	**-0.023**	**-0.039**	**-0.009**
Market framework	0.008	-0.004	0.020	0.008	-0.004	0.021	0.013	-0.006	0.031
Relative teachers' renumeration	-0.041	-0.092	0.009	-0.041	-0.093	0.013	**-0.014**	**-0.211**	**-0.061**
Resource allocation	-0.001	-0.014	0.012	-0.001	-0.015	0.012	-0.004	-0.023	0.015
Budget management	-0.008	-0.020	0.004	-0.008	-0.020	0.005	**-0.029**	**-0.047**	**-0.011**
Market framework	0.007	-0.003	0.018	0.008	-0.003	0.019	0.012	-0.004	0.028
Relative teachers' renumeration	-0.052	-0.105	0.001	-0.052	-0.106	0.001	**-0.154**	**-0.229**	**-0.075**
Resource allocation	0.007	-0.008	0.021	0.007	-0.008	0.022	0.007	-0.016	0.029
Budget management	-0.004	-0.013	0.006	-0.003	-0.013	0.006	**-0.019**	**-0.034**	**-0.004**
Market framework	0.004	-0.008	0.015	0.003	-0.007	0.014	0.003	-0.014	0.020
Relative teachers' renumeration	**-0.050**	**-0.100**	**0.000**	**-0.050**	**-0.098**	**-0.002**	**-0.016**	**-0.234**	**-0.087**

Note : A stands for confidence intervals derived from pseudo distribution. Estimates are bolded if the confidence interval does not include zero.

Table A11. **School-level decision making autonomy and technical efficiency of the median school**
Coefficient estimates from correlations between technical efficiency estimates and institutional indicators

	Non-increasing returns to scale			Variable returns to scale			Constant returns to scale		
	Coefficient estimate	A		Coefficient estimate	A		Coefficient estimate	A	
		Lower (2.5)	Upper (97.5)		Lower (2.5)	Upper (97.5)		Lower (2.5)	Upper (97.5)
Input orientation									
All domains	**-0.002**	**-0.003**	**0.000**	**-0.002**	**-0.003**	**0.000**	**-0.002**	**-0.003**	**0.000**
Instruction	**-0.003**	**-0.005**	**-0.001**	**-0.003**	**-0.005**	**-0.001**	**-0.003**	**-0.005**	**-0.001**
Personnel	-0.001	-0.002	0.000	-0.001	-0.002	0.000	**-0.001**	**-0.002**	**0.000**
Planning	**-0.001**	**-0.002**	**0.000**	**-0.001**	**-0.002**	**0.000**	**-0.001**	**-0.002**	**0.000**
Resources	-0.001	-0.002	0.000	-0.001	-0.002	0.000	-0.001	-0.002	0.000
Output orientation									
All domains	-0.001	-0.001	0.000	-0.001	-0.001	0.000	**-0.002**	**-0.003**	**0.000**
Instruction	**-0.002**	**-0.002**	**0.000**	**-0.002**	**-0.002**	**0.000**	**-0.003**	**-0.005**	**-0.001**
Personnel	-0.003	-0.001	0.000	0.000	-0.001	0.000	**-0.001**	**-0.002**	**0.000**
Planning	0.000	-0.001	0.000	0.000	-0.001	0.000	**-0.001**	**-0.002**	**0.000**
Resources	0.000	-0.001	0.001	0.000	-0.001	0.001	-0.001	-0.002	0.000

Note : A stands for confidence intervals derived from pseudo distribution. Estimates are bolded if the confidence interval does not include zero.

Table A12. **Determinants of technical efficiency at the school level:**
with teaching qualifications replacing teaching certification

	Coefficient estimate		Confidence intervals derived from pseudo distribution: Lower (2.5)	Upper (97.5)
A. Input orientation				
Size (x100)	-0.014	**	-0.015	-0.013
Government-dependent private	-0.028	**	-0.047	-0.010
Independent private	0.065	**	0.038	0.093
Teacher qualifications	-0.075	**	-0.094	-0.053
Some streaming	0.009		-0.005	0.023
Complete streaming	0.015	**	0.001	0.030
Assessment: medium	-0.010		-0.023	0.003
Assessment: high	-0.007		-0.025	0.011
Selectivity: considered	-0.001		-0.014	0.011
Selectivity: priority	-0.032	**	-0.049	-0.014
Selectivity: pre-requisite	-0.048	**	-0.064	-0.031
B. Output orientation				
Size (x100)	-0.006	**	-0.007	-0.005
Government-dependent private	-0.021	**	-0.036	-0.007
Independent private	0.006		-0.017	0.027
Teacher qualifications	-0.061	**	-0.077	-0.043
Some streaming	0.011		-0.001	0.021
Complete streaming	0.015	**	0.003	0.025
Assessment: medium	-0.004		-0.014	0.006
Assessment: high	0.003		-0.011	0.016
Selectivity: considered	-0.004		-0.014	0.005
Selectivity: priority	-0.045	**	-0.059	-0.031
Selectivity: pre-requisite	-0.074	**	-0.086	-0.061

Note : a negative sign indicates lower levels of inefficiency.

** Indicates that the confidence interval does not encompass zero, giving an indication of the statistical significance of the estimate.

Table A13. **Determinants of technical efficiency at the school level:**
the impact of teaching and physical resources

	Coefficient estimate		Confidence intervals derived from pseudo distribution	
			Lower (2.5)	Upper (97.5)
A. Input orientation				
Size (x100)	-0.014	**	-0.015	-0.013
Government-dependent private	-0.024	**	-0.043	-0.005
Independent private	0.071	**	0.040	0.099
Teacher qualifications	-0.075	**	-0.096	-0.054
Some streaming	0.010		-0.004	0.023
Complete streaming	0.017	**	0.003	0.031
Assessment: medium	-0.010		-0.023	0.003
Assessment: high	-0.007		-0.021	0.010
Selectivity: considered	-0.001		-0.014	0.011
Selectivity: priority	-0.031	**	-0.050	-0.013
Selectivity: pre-requisite	-0.047	**	-0.064	-0.032
Quality: teaching resources	-0.004		-0.010	0.003
Quality: physical infrastructure	0.002		-0.004	0.008
B. Output orientation				
Size (x100)	-0.006	**	-0.007	-0.005
Government-dependent private	-0.024	**	-0.039	-0.008
Independent private	0.002		-0.020	0.025
Teacher qualifications	-0.062	**	-0.078	-0.045
Some streaming	0.011		0.000	0.022
Complete streaming	0.015	**	0.004	0.026
Assessment: medium	-0.004		-0.015	0.006
Assessment: high	0.003		-0.012	0.016
Selectivity: considered	-0.004		-0.014	0.005
Selectivity: priority	-0.045	**	-0.058	-0.031
Selectivity: pre-requisite	-0.072	**	-0.085	-0.059
Quality: teaching resources	-0.009	**	-0.014	-0.003
Quality: physical infrastructure	0.002		-0.003	0.007

Note : a negative sign indicates lower levels of inefficiency.

** Indicates that the confidence interval does not encompass zero, giving an indication of the statistical significance of the estimate.

Table A14. **Quality of resources and performance**
Stochastic frontier analysis

	Coefficient	Cluster-robust Z score
Constant	5.147	49.07
Teacher-student ratio	0.035	1.13
Computer availability	-0.015	-0.70
Socio-economic background	0.463	14.95
Language background	0.109	5.78
Teacher-student ratio*teacher-student ratio	-0.048	-2.90
Computer availability*computer availability	-0.009	-1.94
Teacher-student ratio*computer availability	0.020	2.00
School size (x100)	0.002	2.43
Government-dependent private	0.018	1.96
Independent private	-0.003	-0.17
Teacher qualifications	0.008	0.79
Autonomy resources	-0.006	-2.49
Autonomy curriculum	0.007	1.51
Some streaming	-0.004	-0.68
Complete streaming	-0.016	-2.19
Assessment: medium	-0.002	-0.47
Assessment: high	-0.014	-2.29
Selectivity: considered	0.001	0.21
Selectivity: priority	0.022	2.91
Selectivity: pre-requisite	0.045	5.18
Quality of material resources	0.002	0.95
Quality of teaching resources	0.007	3.27
Lambda	2.38	

Note : The table presents the estimated coefficients and associated cluster-robust Z-scores for a translog production function assuming a half-normal distribution. A positive coefficient signifies a postive relationship with average performance in PISA tests.

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